Ergonomics Research Laboratory
Queen's University at Kingston
School of Physical & Health Education
Department of Mechanical Engineering

Development of Minimum Physical Fitness Standards for the Canadian Armed Forces

DSS Contract # 8SE85-00017
DEFENCE & CIVIL INSTITUTE FOR ENVIRONMENTAL MEDICINE

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7 November 1985.

Dr. W.S. Myles,
Defence and Civil Institute of
Environmental Medicine,
1133 Sheppard Avenue West,
P.O. Box 2000,
Downsview, Ontario. M3M 3B9.

Dear Dr. Myles:

Please find enclosed twelve (12) copies of the final report with Contract Serial Number 8SE85-00017 entitled "Development of Minimum Physical Fitness Standards for the Canadian Armed Forces." We trust that you will find all aspects of our report clear and explicit. Do not hesitate to call if we can be of further service on this contract or on additional research questions which may arise on fitness standards or other such projects. We conclude that this completes all requirements of the first phase of the contract.

Respectfully submitted,

Joan M. Stevenson

JMS/s

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DEVELOPMENT OF MINIMUM PHYSICAL FITNESS STANDARDS FOR THE CANADIAN ARMED FORCES

submitted by

SCHOOL OF PHYSICAL AND HEALTH EDUCATION
DEPARTMENT OF MECHANICAL ENGINEERING

QUEEN'S UNIVERSITY AT KINGSTON

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to

DEFENCE AND CIVIL INSTITUTE FOR ENVIRONMENTAL MEDICINE

Contract No.: 8SE85-00017

Contract Issue Date: April 25, 1985.

Final Report Date: November 21, 1985.

Scientific Authority: Dr. W.S. Myles

PREFACE

This study undertook the development of physical fitness standards commensurate with satisfactory performance of identified common military tasks. Components of physical fitness essential to performing these tasks were first identified. From this, standard measures of physical fitness were selected which could best predict task performance. Included in physical fitness measurements were the EXPRES protocol, standard laboratory techniques, and the Incremental Lifting Machine (ILM) protocol.

Preliminary laboratory work revealed five tasks considered to have significant fitness requirements. Suitable field tests were developed so that performance could be quantified during the formal experiments. At CFB Kingston, 61 males and 19 females were observed in a Land Stretcher Carry task, an Entrenchment Dig task, and a Low/High Crawl manoeuver. At CFB Halifax, 33 males and 11 females were observed were observed in a Fire-Fighting simulation and a Stretcher Carrying activity between ship decks.

Correlation between EXPRES measurements and standard laboratory measurements indicated EXPRES to be a reasonable measure of general physical fitness. Physiological measurements suggested that the five tasks examined had substantial fitness components. However, it was not possible to predict performance in these tasks from fitness measurements alone.

In order to establish fitness standards, an empirical model was developed. This model gave scores for fitness variables found to be components of task performance. Minimum scores for these fitness variables were established by finding the scores above which 95% of the passing males population achieved. It was not possible to find similar scores for women.

It is recommended that the EXPRES protocol continue to be developed and improved as a measure of physical fitness in the CF, and that minimum fitness standards be established for common military tasks. As a basis for this, the empirical model for males is recommended for adoption pending appropriate validation studies. It is further recommended that a similar approach be undertaken to establish standards for women. To improve the predictability of task performance, it is recommended that additional ergonomic measurements be combined with fitness measurements. Furthermore, it is recommended that Common Tasks be described in terms of global objectives rather than specific activities.

The report is divided into three sections. Section A, The Summary Report, is a consolidation of findings from all aspects of the study. Included are essential descriptions of objectives and work plan, task selection, experimental protocol, methods, results, and statistical analyses. Also included in The Summary Report is a discussion of limitations of the study, evaluation of the seven common tasks, recommendations for EXPRES, and implications of the empirical model approach. Conclusions and Recommendations of the study are summarized in Section A8.

Detailed Experimental Reports are contained in Section B. In each of seven sections, individual experiments are described fully with documentation regarding protocol, results, and analysis. These reports describe the fitness measurements performed, each of the five tasks studied, and the Incremental Lifting Machine protocol.

The final section of the report includes appendices which document all of the raw data used in the study. These have also been provided on magnetic medium under separate cover.

This project was truly a team effort. I wish to acknowledge the impetus and guidance of Dr. Stewart Myles (DCIEM) and Major Earl Morris. In addition, personnel from CFB Kingston and Halifax and staff of the Fire-Fighting Training School were very supportive during the pilot studies and data collection. Daily contract management was under the capable leadership of Sheryl French-Scott, in conjunction with research assistants, Chris McCarley, Tim Lapp and Dan Morton. Special thanks is due for the assistance of Dr. Gavin Reid during field studies. And last, for the loyal and steadfast work and ideas of my collegues, George Andrew Ph.D., Tim Bryant Ph.D., P.Eng., and John Thomson, Ph.D., I offer my gratitude.

J. M. Stevenson, Ph.D.
November 20, 1985.

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THE SUMMARY REPORT

SECTION A

A1. DIRECTIVE OF CONTRACT

A1.1. Statement of Problem

In times of emergency, there are certain common duties which all military personnel, regardless of trade classification, age or sex, may be expected to perform. Based on this basic principle, the Canadian Armed Forces (CF) wished to determine the minimum physical fitness standards (MPFS) which would ensure adequate performance of such tasks by all. It is this specific problem which the Ergonomics Research Laboratory at Queen's University has been contracted to study; the contract was issued through the Applied Physiology Section at DCIEM on behalf of the Director of Physical Education and Recreation Amenities (DPERA).

A1.2. Statement of Purpose and Objectives.

The specific purpose of the contract was to attempt to develop physical fitness standards which are commensurate with satisfactory performance of the identified common military tasks. This contract was undertaken to assist in the identification of those tasks within the common tasks which were physically demanding and to evaluate the ability of EXPRES to measure the performance of those tasks. More specifically the objectives of this study were:

A1.2.1 To identify and quantify those components of physical fitness essential in performing the physically demanding components of the common tasks.

A1.2.2 Based on this information, to select and/or develop field tests of physical fitness that might measure performance ability of these tasks.

A1.3. Work Plan.

The work plan of the contract was comprised of two phases. Phase I was intended to meet a short-term objective; specifically to meet deadlines imposed by DPERA for the tentative proposal of physical standards which will apply to the existing EXPRES fitness testing protocol. Phase II, the long term objective but not part of the present contract, is intended to provide a more definitive answer as to fitness components, test protocols and minimum standards of physical fitness; this latter objective will entail more extensive laboratory research. The work plan of Phase I was composed of the following:

A1.3.1 Literature Survey to attempt to rationalize the relative physical demands of some of the common tasks.

A1.3.2 Field Trips to CFB Halifax and Kingston for observation of tasks and limited data collection; these data to be used in refining tasks and developing test protocols.

A1.3.3 Laboratory tests to simulate the selected common tasks to be studied in field testing.

A1.3.4 Field testing at the above CF Bases during which the field tests (task performance), a battery of laboratory measures as well as EXPRES were determined.

A2. TASK SELECTION

A2.1. The Identified Common Tasks.

Seven common military tasks which all CF Personnel might be expected to perform in time of emergency were identified and defined by DPERA with input from various NDHQ Directorates and units such as the CF Survival School. The tasks were:

A2.1.1 Operate one's personal weapon (eg., "Shoot to live" test);
A2.1.2 Effectively function in NBCW clothing;
A2.1.3 Carry out Casualty Evacuation and First Aid;
A2.1.4 Perform Fire-fighting duties;
A2.1.5 Execute survival, search and rescue techniques;
A2.1.6 Perform general security duties;
A2.1.7 Perform above duties (A2.1.6) with NBCW attire.

Since not all of these tasks may require a high physical fitness standard, they were examined in light of the available literature and preliminary testing by the research group to determine those specific tasks which were the most physically demanding; thus, adequate performance of these tasks so identified would ensure capability of carrying out those which are less demanding.

A2.2. Selected Tasks Requiring Significant Physical Fitness.

The selected tasks, some of which were components of the above common tasks, examined in the contract were the following:

A2.2.1 Team Land Stretcher Carry. Two-person team, using a stretcher to evacuate a normal person (80kg.) across rough terrain a distance of 1 km (CFB Kingston).
A2.2.2 Entrenchment Dig. Each person digging a one-person entrenchment 6 ft. long, 2 ft. wide and to a depth of 18 in. in soil of moderate firmness with no rocks or large roots (CFB Kingston).
A2.2.3 Low/High Crawl. Each soldier performing a low crawl (all body parts close to the ground) for 30 m, turning 180 degrees, and do a high crawl (on hands and knees) for 45 m (CFB Kingston).
A2.2.4 Team Sea Stretcher Carry. Two-person team, while in fire-fighting gear, using a stretcher to evacuate an 80 kg person a horizontal distance of 25 m followed by moving the stretcher up and down one deck (CFB Halifax).
A2.2.5 Fire Fighting. In fire-fighting gear and using breathing apparatus and in varying temperatures, control 50 ft. (15 m) of charged hose for 30 minutes climbing and descending one deck (CFB Halifax).

A3. EXPERIMENTAL PROTOCOL

Based on the survey of the relevant available literature, field observations, as well as subsequent laboratory testing, the tests to be carried out on military personnel at CFB Kingston and CFB Halifax were selected. This included three groups of tests.

Field Tests - comprised of the selected common tasks found most physically demanding.

Laboratory Tests - items selected from extensive preliminary testing comparing laboratory measures and field test performance.

EXPRES Test - the standard test battery currently applied in CF, and administered by trained CF personnel in the present contract.

Details of the field and laboratory test items, as contained in the Queen's University "Individual Subject Materials" (Appendix A), were provided for all subjects in advance of testing; EXPRES test items had been previously described to and performed by all at their CF Base. For convenience the test items are listed below:

A3.1. <u>Field Tests.</u>

The field tests selected for study have been described briefly above and in greater detail in the contract. The three "land" tests - land stretcher carry, entrenchment dig and low/high crawl were performed at CFB Kingston. The "sea" tests, comprised of a stretcher carry between decks and fire fighting, were carried out at CFB Halifax.

A3.2. <u>Laboratory Tests</u>.

The Laboratory test items, performed at the "Queen's" testing station, included the following:

A3.2.1 ILM Lifting. The Incremental Lifting Machine (ILM), previously applied in testing of military personnel, was employed to determine the maximum lift to heights of six feet (ILM-6) and five feet (ILM-5); the protocol followed had been developed in an earlier contract. The test is a measure of strength (muscle power) and coordination of the total body.

A3.2.2 Wingate Test (Leg). A cycle (leg) ergometer test to assess "anaerobic" power which entailed high intensity, short duration, supra-maximal work. Computer assistance was used in the data collection and calculation.

A3.2.3 Wingate Test (Arm). An arm ergometer was employed in a protocol comparable to the leg test (above) as an indicant of upper body "anaerobic" power.

A3.2.4 Skin Fold Thickness. A simple, indirect estimate of body fat was determined using the skin-fold caliper.

A3.2.5 Flexed Arm Hang. The body mass was supported at a fixed hanging position, with arms bent, chin above bar level until fatigue. (This test is thought to assess so-called "anaerobic" endurance of the climbing muscles of the arms and shoulders.)

A3.2.6 Endurance Grip Hold. This entailed sustaining a grip at a fixed intensity for as long as possible. (As for the above, this test is considered to reflect "anaerobic" endurance of the hand-grip muscles.)

A3.2.7 Maximal Aerobic Capacity (Predicted). The Astrand-Rhyming protocol, employing a 6 minute sub-maximal workload, was performed on a cycle (leg) ergometer. (This test is a predictor of "aerobic" endurance.)

A3.2.8 Venous Blood Lactate. Lactate was determined after the leg ergometer test (A3.2.2), the Low/High Crawl and following the sea stretcher carry. This measure of the "anaerobic" energy expenditure during these tasks was compared to subjects' maximal lactate values determined during the leg Wingate test.

A3.3. EXPRES Tests.

Four items are contained in this battery: timed number of situps and maximum number of pushups as measures of muscle "anaerobic" power, the Canada Fitness step-test as an indirect measure of "aerobic" capacity, and combined left and right maximal hand grip score.

A4. METHODS

The specific test items carried out were described above; this section describes the design of the testing and matters relating to data processing.

A4.1. Subject Selection.

On a directive from DPERA, a population of military personnel were selected from Kingston LandOps, Kingston Support Personnel and Trenton Personnel to conduct the land aspects of the study. The population for the sea components of the study were selected from the Halifax Shipboard and Land Personnel. In all, 132 subjects (33 women, 99 men) completed the testing.

A4.2. Test Sequence.

Details of the proposed testing schedule are provided in the Queen's "Manual of Schedules and Protocols" (Appendix G). In practice, this schedule could not be rigidly applied for assorted legitimate reasons. Any given group was tested over a two-day period. Following briefing on the nature and purposes of the tests, groups rotated through the four (Kingston), or three (Halifax) testing stations. At each station, a short teaching session was held prior to testing. In principle the testing allowed ample time for full recovery from the previous exercise and the two most difficult tasks were normally performed on separate days.

A4.3. Data Handling.

For each testing station, trained assistants fully versed with the tests were responsible for conducting them. This included recording of results on data sheets and ensuring that the testing criteria were met. The data were then filed on disk using on-site microcomputers for later compilation and analysis.

A4.4. Statistical Analyses

Statistical analyses were performed to accomplish four general goals.

A4.4.1 Identification of the difference between men and women in performance of the various military tasks as well as the EXPRES and laboratory tests: this involved graphic comparison of scores for men and women for each test variable.

A4.4.2 Identification of the fitness components of each of the four tasks in which failures occured (i.e., Land and Sea Evacuation Tasks, Low/High Crawl and Entrenchment Dig) in terms of the EXPRES and other measures: it was assumed that the occurence of a relatively large and significant measure of association (i.e., a Pearson correlation coefficient) between a task and an EXPRES or other laboratory test variable would indicate that the fitness parameter measured by the simple test in this relationship was also an important component in the performance of the more complex military task. The actual analysis involved two stages: first, computation of simple correlation coefficients to indicate a simple one-to-one relationship between only two variables: second, computation of multiple correlation coefficients to indicate the strength of a many-to-one relationship. The latter was accomplished with multiple regression (using the stepwise approach) which provide a measure of the interrelationships between many variables, such as those of EXPRES relative to a more complex variable such as the military tasks;

A4.4.3 Determination of the effective discriminant ability of the EXPRES fitness parameters according to the subject achieving (i.e., passing and failing) individual task criteria. The EXPRES variables were subjected to discriminant analysis. In this procedure, a linear combination of variables (i.e., EXPRES measures) is used to distinguish between two or more groups - in this case, the people that passed a given military task versus those that failed the particular task. The variables "discriminate" between persons in these two groups and predict into which category or group each falls, based on the values of the variables. The procedure is, in fact, two staged: first, identification of the linear combination which best separates groups; then, application of this function to the data to 'test' for the practical effectiveness of the obtained function.

A4.4.4 Determination of the minimum level of performance (MPFS), predicted according to the EXPRES score achieved by (male subjects only) who attained the task criteria. This was an empirical method (completed for male subjects only due to the very small number of women in the sample) in which the lower limits of the 95% confidence interval and 99% confidence interval were calculated for the mean of each of the EXPRES and other "predictive" test variables.

A5. DESCRIPTIVE RESULTS

The data is presented below under five headings. In this section, each component is dealt with separately, without reference or relevance to other data; in the section following, inter-relationships between variables are examined.

A5.1. Physical Characteristics of Subjects.

Mean, standard deviation and range values are presented in Table A1. Thirty-three females and 99 males completed all tests. Mean ages for both the men and women were in the mid-to-upper 20's, however, the subject population ranged from 19 to 51 years. Values for height, weight and body fat were in the range of expected normal values.

A5.2. Population Distribution by EXPRES.

Distribution of the subjects on the basis of EXPRES percentile score are shown in Table A2. The preponderence of scores fall at or above this "minimum" fitness score in all variables for both men and women. This would place the subjects in the upper half of the expected normative distribution when adjusted for both age and gender. This indicates a non-randomized distribution in subject selection and suggests that on average the present population would be considered above average in physical fitness, according to EXPRES variables.

One implication following from this "natural" selection (i.e., the more fit will volunteer more readily than the less fit) is that both task performance, and other fitness-related variables measured, would be biased, thus rendering prediction of an MPFS on the basis of these data hazardous.

A5.3. Summary of EXPRES Tests.

Table A3 includes mean values for the four items contained in EXPRES. Measurements of a fifth variable (i.e., chinups) were made but preliminary analysis of these limited data indicated no improvement with addition of this variable as a predictor of performance; thus, these data are not included. Raw Scores, rather than percentiles, are presented in Table A3; however, because of the age distribution of the subjects, a single mean percentile score is of limited value. When the mean values for the group mean age are expressed as a single percentile, for all variables the values are well above the 50th percentile (i.e., 60, 85, 85 and 65%ile for MV02, Combined Grip Strength, Pushups and Situps respectively for men; corresponding values for women were 75, 90, 95 and 90 %ile). These data indicate further the inherent bias in the present subject selection process.

TABLE 1. Summary of Physical Characteristics of C.F. Personnel in Study for Minimum Physical Fitness Standards. (Means, Standard Deviations, and Ranges[1])

SUBJECT POPULATIONS	AGE (yrs)	HEIGHT (cm)	WEIGHT (kg)	BODY FAT (%)
FEMALES				
Kingston (n=21)				
Mean	25.6	165.0	61.8	24.7
S.D.(+/-)	4.7	4.3	9.1	6.3
Range	21-37	155-173	49-92	14-38
Halifax (n=12)				
Mean	25.7	165.5	61.4	27.4
S.D.(+/-)	5.1	6.4	5.1	4.4
Range	21-28	154-174	52-72	22-37
MALES				
Kingston (n=63)				
Mean	27.4	173.3	77.7	16.2
S.D.(+/-)	8.7	16.0	14.9	4.5
Range	19-51	155-196	49-101	6-33
Halifax (n=36)				
Mean	29	173.8	76.4	19.2
S.D.(+/-)	7.3	18.0	9.4	5.0
Range	21-40	83-188	60-98	9-31

[1] Range values rounded to nearest whole number.

TABLE A2. Population Distribution by EXPRES Percentiles.

TEST VARIABLES	KINGSTON MEN	KINGSTON WOMEN	HALIFAX MEN	HALIFAX WOMEN	COMBINED MEN	COMBINED WOMEN
OXYGEN CONSUMPTION (ml/kg/m)						
Excellent	11	1	0	1	11	2
Good	22	9	13	7	35	16
Minimum	23	7	17	3	40	10
Below Min.	2	1	3	0	5	1
Poor	0	0	1	0	1	0
COMBINED GRIP (kg)						
Excellent	11	4	2	2	13	6
Good	27	9	10	7	37	16
Minimum	20	5	2	16	22	21
Below Min.	0	0	3	0	3	0
Poor	0	0	1	0	1	0
PUSHUPS (no.)						
Excellent	22	12	4	5	26	17
Good	22	6	11	6	33	12
Minimum	16	0	13	0	27	0
Below Min.	0	0	3	0	3	0
Poor	0	0	0	0	0	0
SITUPS (no.)						
Excellent	12	5	1	2	13	7
Good	21	7	6	6	27	13
Minimum	22	6	16	2	38	8
Below Min.	5	0	10	1	15	1
Poor	0	0	0	0	0	0

LEGEND

1 - excellent	97 - 100%	
2 - good	75 - 96%	
3 - minimum	25 - 74%	
4 - below minimum	4 - 24%	
5 - poor	<3%	

TABLE A3. Summary of EXPRES Variables in Combined Groups.

SEX	MVO2 MAX. ml/kg/min.	COMB. GRIP kg.	PUSH-UPS no.	SIT-UPS no.
MALES				
Mean	48.9	111.1	36.9	38.3
S.D.(+/-)	6.8	13.5	11.2	10.0
Range	29-61	67-148	11-60	10-70
FEMALES				
Mean	37.5	66.0	41.2	39.1
S.D.(+/-)	3.5	13.4	11.5	11.4
Range	31-44	48-93	24-60	17-61

A5.4. Summary of Laboratory Tests.

Mean values for the laboratory test items are listed in Table A4 for men and women with the groups combined. These items were selected from the battery of laboratory tests applied in the preliminary testing. For most of these tests their inclusion was intended to provide objective measurements, such as strength and other physical fitness components, to which both the field test performance and EXPRES scores could be compared.

ILM-6 is a strength measure of lifting capacity. The mean values were 49.5 and 26.4 kg for men and women, respectively; these values fall considerably above our earlier OPSS data on students as well as U.S. data on military personnel (i.e., 40 and 21.5 kg for men and women). This might be expected for two reasons: The average EXPRES scores of the present group, as discussed above, suggested either a select population or that the use of an altered free-style ILM protocol based on an objective assessment improved subjects' scores. The use of lower weight increments for the women on our modified ILM (i.e., 2.3 vs 4.6 kg) was also instrumental in improving the scores with this gender.

Arm and leg ergometer power scores were included because of their high "anaerobic" demand; for this reason the associated measure of anaerobiosis - blood lactate - was also included. Values for the latter measure support the conclusion that these tests were in fact highly anaerobic in nature. Normative data for arm and leg ergometer, for the present population, are not at hand; similarly, for flexed arm hang and the combined endurance grip measures.

A5.5. Summary of Field Tests

Mean values for the five test items included in this test battery are given in Table A5. Within each item, selected measured variables which were found important in subsequent data analysis are also provided. These test items represent components of the three common military tasks included in the present study (i.e., Tasks 3,4 and 6 see 2.1 or Appendix A for the seven identified common tasks).

Table A6 summarizes the pass/fail results on the five performance tasks expressed as percentage both for the preliminary study (Appendix D) (which data was used to refine and/or develop the selected field test items) and for the five field tests according to the final protocol. In this regard, several points should be noted. Firstly, detailed preliminary testing on fire fighting was carried out in order to find a discriminating component of this task (Appendix D); this series clearly failed to lead us to a satisfactory field test, as outlined in the workplan (since all subjects passed). Thus, no spread in performance scores were obtained, and for this reason, no further analysis on these data could be carried out.

Secondly in Table A6, common test items 6c (lift and carry) and 6e (run and shoot) were rejected as final field test items since they were not found to be physically demanding variables as suggested by the high

TABLE A4. Summary of Laboratory Tests for Combined Groups[1]

TEST ITEMS	MEN			WOMEN		
	MEAN	S. D. (+/-)	RANGE	MEAN	S. D. (+/-)	RANGE
ILM TEST 6' (kg)	49.5	8.7	24-84	26.4	5.8	19-50
ERGOMETER ARM (kpm)	1525.2	192.9	1008-1896	829.3	145.7	504-1190
ERGOMETER LEG (kpm)	3139.7	479.9	1991-4406	2108.1	256.2	1663-2671
LEG LACTATE (mg%)	73.5	14.2	46-108	58.3	10.8	41-82
FLEXED ARM HANG (min)	47.0	13.2	10-76	24.6	16.8	0-69
% BODY FAT (%)	17.4	4.8	6-30	25.7	6.0	14-38
ENDURANCE GRIP (sec) COMBINED	239.3	85.6	84-600	84.7	45.7	30-228

[1] Range values rounded to nearest whole number. Astrand-Rhyming data not included.

TABLE A5. Summary of Field Tests by Sex.

TEST ITEM	MEN			WOMEN		
	MEAN	S.D.	RANGE	MEAN	S.D.	RANGE
A. KINGSTON						
LAND STRETCHER CARRY						
TIME (min)	15.7	4.4	8-27	42.9	24.7	17-110
H.R. (bpm)	171.0	11.5	144-222	168.7	14.5	132-198
D.R. (m)	292.0	137.8	80-800	109.3	45.0	40-190
T.R. (min)	3.1	1.3	1-8	1.5	0.7	1-3
LOW/HIGH CRAWL						
LOW (s)	36.5	7.1	24-60	78.5	26.3	48-140
HIGH (s)	40.1	8.5	29-86	70.0	51.5	46-290
TOTAL (s)	76.6	14.4	55-139	148.6	70.2	94-420
H.R. (bpm)	183.9	13.3	156-204	180.9	13.3	156-198
LACTATE (mg%)	73.8	9.4	57-100	63.9	8.7	47-82
ENTRENCHMENT DIG						
TIME (min)	51.6	17.7	26-102	92.8	22.7	62-120
H.R. (bpm)	183.6	13.3	156-204	182.7	13.0	156-198
B. HALIFAX						
SEA STRETCHER CARRY						
TIME (s) T-1	127.4	41.2	69-233	430.0	13.9	422-446
T-2	119.4	46.4	73-221	-	-	---
H.R. (bpm) T-1	159.6	31.6	114-198	170.0	11.2	150-180
T-2	165.1	32.0	150-204	-	-	---
LACTATE (mg%)	59.7	15.3	39-89	70.2	8.2	61-86
FIRE FIGHTING	PASS/FAIL BASIS ONLY: ALL SUBJECTS PASSED					
H.R. (bpm)	163.5	16.8	115-187	165.4	12.8	147-187

LEGEND

- H.R. - heart rate
- D.R. - distance to 1st rest
- T.R. - time to 1st rest
- T-1 - trial 1
- T-2 - trial 2

TABLE A6. Summary of Pass / Fail Percentages: Personnel Achieving M.P.F.S. Performance Criteria as Outlined in the Guidelines for Tasks which have a Physical Fitness Component.

COMMON TASKS	KINGSTON AND HALIFAX FIELD TESTS			
	PRELIMINARY STUDY MAY, 1985		FORMAL STUDY JULY, 1985	
	MEN	WOMEN	MEN	WOMEN
3.a) Land Stretcher Carry	86%	33%	88%	11%
b) Ship Stretcher	100%	33%	100%	50%
4. Fire Fighting[1]	100%	100%	100%	100%
6. General Security Duties				
b) Entrenchment Dig[2]	100%	33%	37%	0%
c) Lift and Carry	100%	86%	-	-
d) Low/High Crawl	66%	0%	87%	0%
e) Run and Shoot	100%	100%	-	-

[1] Test protocol modified to be more realistic.
[2] Soil conditions were 97% packed clay and thus more difficult than the guidelines.

pass rate. Thirdly, on common task item 6b (entrenchment dig) the discrepancy between preliminary and field test scores should be noted; this high failure rate in the final field test is attributed to the high compaction (97%) of soil, which incidently occurred between testing dates, May vs July, and possible other factors (eg., incidence of rock, moisture content, air temperature etc.). As a consequence, this test item was of limited value in the discriminant analysis.

Fourthly, there was a higher failure rate of women in the land stretcher carry, the entrenchment dig and low/high crawl than anticipated from the preliminary data. This occurred despite the high EXPRES scores achieved by the group. It is clear that completion of these tasks as presently designed was difficult for this female population, however further data and refined tasks are necessary before conclusive assessments can be made for women.

On the basis of terminal heart rate measurements, as shown in Table A5, the relative intensity of each task can be estimated: clearly each task would be rated as intense. The land stretcher carry, which required an average 15.7 minutes for men and 42.9 minutes for women, with corresponding heart rates of 171 and 168.7 bpm, must be considered as essentially an "aerobic" activity; similarly, this would be so for the entrenchment dig and fire fighting. The high blood lactate values following the low/high crawl and sea stretcher carry, both of which were of shorter duration, reflected the high level of "anaerobic" involvement in these tasks.

A6. STATISTICAL ANALYSES

A6.1. Introduction.

The objective of the analysis of interrelationships was to determine correlation between task performance and fitness measures. First, simple correlation was measured between individual fitness parameters and task performance scores. These were considered independently for males and females. Second, multiple linear regression analysis was used to determine whether or not several individual variables interacted and subsequently correlated with task performance. Both these methods tested the assumption that a linear relationship exists between fitness measurement and task scores. Implicit in this analysis is the assumption that the dependent and independent variables are continuous.

An alternative to continuous variable methods involves the selection of cut-off points for task peformance. Here, a predetermined score is used to divide the population into groups of passers and failers. In the third statistical analysis, the variables which could best discriminate passing and failing groups were determined. In the final analysis, an empirical model was devised which represented the minimum fitness scores required to have a reasonable probability of meeting passing criteria for selected tasks.

A6.2. Simple Correlation Analysis

In the simple correlation analysis, individual fitness test parameters were compared to task performance scores using linear regression. Individual fitness parameters were measured as described in Section 5. These included all of the variables listed in Tables A7 and A8. Task scores based on total time were determined for the land stretcher carry task, the low/high crawl, the entrenchment dig, and the sea stretcher carry task.

The regression coefficients (r) for fitness parameters versus tasks scores are shown in Tables A7 and A8 for males and females respectively. Values indicated by a asterisk (*) are those correlations which had significance above the 95% confidence limit ($p < .05$). None of the simple correlations had a high regression coefficient. For the males, the best observed values were 0.66 and 0.65 for leg and arm ergometer on the sea stretcher carry. Females had slightly better fits in which the r value for the entrenchment dig exceeded 0.7 for two fitness parameters.

In general, simple correlation did not provide a reliable method by which task performance could be predicted. However, the incidence of several cases in which the correlation was significant provided useful insight into the nature of the tasks. A highly significant correlation indicates that the fitness parameter measured is, with a high probability, related to the task being observed. A poor regression coefficient suggests that a high variance exists in the measurement of both the fitness parameter and the task performance. Thus, while it is not possible to predict task performance from a fitness parameter

TABLE A7. Correlations (r) Between Performance Measures and Selected Fitness Components for Men.

FITNESS PARAMETERS	LAND EVACUATION (n=60)	LOW/HIGH CRAWL (n=61)	ENTRENCHMENT DIG (n=58)	SEA EVACUATION (n=22)
1. ANTHROPOMETRY:				
Age	-0.15	0.31*	0.13	0.40*
Height	-0.14	0.13	-0.10	-0.09
Weight	-0.24	-0.04	0.01	-0.09
% Body Fat	0.05	0.34*	0.27*	0.31
2. STRENGTH MEASURES:				
A. Upper Body				
Combined Max.				
Grip (raw)+	-0.22	0.05	0.03	-0.43*
(%ile)+	-0.28*	0.05	0.02	-0.50*
Arm Power	0.03	-0.05	-0.01	-0.65*
B. Lower Body				
Leg Power	-0.30*	-0.20	-0.05	-0.66*
C. Total Body ILM 6'	-0.06	-0.23	-0.18	-0.49*
3. AEROBIC MEASURES:				
Step Test (raw)+	0.08	-0.37*	-0.05	-0.36*
(%ile)+	0.07	-0.22	0.001	-0.23
Astrand-Rhyming	-0.12	-0.05	0.02	-0.04
4. ANAEROBIC MEASURES:				
A. Upper Body				
Pushups (raw)+	0.09	-0.23*	-0.13	-0.31*
(%ile)+	0.15	-0.06	-0.08	-0.21*
Armerg % Fatigue	0.02	0.01	-0.09	n/a
Endurance Grip (combined)	-0.24*	-0.15	-0.05	-0.24*
Flexed Arm Hang	0.04	-0.08	-0.03	-0.21*
B. Abdominal				
Situps (raw)+	-0.13	-0.22	-0.23	-0.44*
(%ile)+	-0.10	-0.03	-0.17	-0.32
C. Lower Body				
Legerg % Fatigue	-0.20*	-0.12	-0.11	n/a
D. Post Exercise Lactate				
Post Leg Erg	0.12	0.003	0.26*	
Post Crawl	-0.17	-0.16	0.10	n/a

* p<.05
\+ EXPRES Variables

TABLE A8. Correlations (r) Between Performance Measures and Selected Fitness Components for Women.

FITNESS PARAMETERS	LAND EVACUATION (n=18)	LOW HIGH CRAWL (n=18)	ENTRENCHMENT DIG (n=12)	SEA EVACUATION[1] (n=6)
1. ANTHROPOMETRY:				
Age	-0.16	0.60*	-0.07	
Height	0.31	-0.31	-0.25	
Weight	0.32	0.001	0.31	
% Body Fat	0.31	0.06	0.30	
2. STRENGTH MEASURES:				
A. Upper Body				
Combined Max.				
Grip (raw)+	-0.28	-0.19	-0.73*	
(%ile)+	-0.16	-0.16	-0.72*	
Arm Power	-0.19	-0.42*	-0.29	
B. Lower Body				
Leg Power	-0.06	-0.51*	-0.05	
C. Total Body ILM 6'	-0.30	-0.37*	-0.33	
3. AEROBIC CAPACITY:				
Step Test (raw)+	-0.16	-0.16	-0.22	
(%ile)+	-0.15	-0.004	-0.31	
Astrand-Rhyming	-0.42	-0.04	-0.42	
4. ANAEROBIC MEASURES:				
A. Upper Body				
Pushups (raw)+	-0.36	-0.39*	-0.64*	
(%ile)+	-0.16	-0.30	-0.51	
Armerg % Fatigue	-0.17	0.29	0.20	
Endurance Grip (combined)	-0.51*	-0.03	-0.36*	
Flexed Arm Hang	-0.43*	-0.40*	-0.67*	
B. Abdominal				
Situps (raw)+	-0.22	-0.51*	-0.52	
(%ile)+	-0.20	-0.47*	-0.56	
C. Lower Body				
Legerg % Fatigue	-0.23	0.21	-0.06	
D. Post Exercise Lactate				
Post Leg Erg	-0.33	-0.23	-0.60	
Post Crawl	-0.33	-0.29	-0.53	

* $p<.05$
\+ EXPRES Variables
[1] Unable to calculate coefficients due to small number of women completing the task.

measurement, it is highly likely that significantly correlated fitness parameters underlie the performance of that particular task.

To highlight these relationships, Table A10. shows the significant correlations between fitness parameters and task performance for males and females. The closed symbols indicate the simple correlations.

A6.3. Multiple Linear Regression

While simple correlation indicated several relationships with high probability values among fitness parameters and task performance, correlations were poor. The multiple linear regression analysis was performed in order to test the possibility that several individual parameters interacted in a way to produce a highly correlated predictive model for task performance. Several regression models were examined by varying the parameters studied. These included examinations of all fitness variables, EXPRES variables alone, laboratory measurements alone, and a forced fit of all variables which required EXPRES variables to be included in the model. The process used was that of stepwise regression in which variables were successively included having passed a test of individual correlation. In most cases, the pass test to be included in the regression model was a $p < 0.05$.

A summary of the results to the multiple linear regression models is shown in Table A9. Indicated here are only those models which had significance levels $p < .05$. An examination of the regression coefficients for the produced equations shows little improvement over the simple correlation case. An exception is noted in the case of the females entrenchment dig. Here, a relatively few number of subjects provided a high r-value. The significance level of this correlation is not greater than the other models presented, and must therefore be viewed as a computational artifact based on the small sample size.

Multiple linear regression provided only marginally better than simple linear regressions. Of importance are highly significant correlations involving up to three independent variables for the models. As with the simple correlations, the high significance indicates that the underlying variables in fact influence the task being measured. The low regression coefficients suggest difficulty in measuring fitness parameters and task performance.

To highlight these results, a summary of the significant regression components is shown in Table A10. Both male and female results are shown. The open symbols indicate those variables related to task performance through a multiple regression equation. In general, all of the fitness variables indicated for a particular task were required in the regression model.

TABLE A9. Summary of Multiple Linear Regression Results.

PERFORMANCE TASKS	VARIABLES	R-SQUARED	p VALUE
MALES			
1. Land Stretcher Carry	Height Weight Sit-ups	0.20	0.007
2. Low High Crawl	Arm Erg. Power % Body Fat ILM-6	0.27	0.001
3. Entrenchment Dig	—	—	—
4. Sea Stretcher Carry	Average EXPRES Leg Erg. Power	0.53	0.001
	All EXPRES %iles Arm Erg. Power	0.63	0.001
	All EXPRES raw Arm Erg. Power	0.64	0.001
FEMALES			
1. Land Stretcher Carry	—	—	—
2. Low High Crawl	Leg Erg. % Fatigue Flexed Arm Hang Arm Erg. Power Endurance Grip (C)	0.97	0.001
3. Entrenchment Dig	Flexed Arm Hang Endurance Grip (C)	0.82	0.003
	Max Grip (C) %ile Flexed Arm Hang	0.87	0.001
	Max Grip (C) raw Flexed Arm Hang	0.93	0.001
4. Sea Stretcher Carry	—	—	—

TABLE A10. Summary of Simple and Multiple Correlations, Significant at $p < .05$. (Variables in which interaction occurred in two or more tasks are denoted by +.)

FITNESS PARAMETERS	LAND EVACUATION (N=60)	LOW/HIGH CRAWL (n=61)	ENTRENCHMENT DIG (n=58)	SEA EVACUATION (n=22)	
1. ANTHROPOMETRY:					
Age		● ■		●	+
Height	⊙				
Weight	⊙				
% Body Fat		● ⊙	●		+
2. STRENGTH MEASURES:					
A. Upper Body					
Max Grip (C) (raw)*			■ ▣	● ⊙	+
(%ile)*	●		■ ▣	●	+
Arm Erg. Power		⊙ ■ ▣		● ⊙	+
B. Lower Body					
Leg Erg. Power	●	■		● ⊙	+
Total Body ILM 6'		⊙ ■		●	+
3. AEROBIC MEASURES:					
Step Test (raw)*		●		●	+
(%ile)*					
Astrand-Rhyming					
4. ANAEROBIC MEASURES:					
A. Upper Body					
Pushups (raw)*		● ■	■	●	+
(%ile)*				●	
Arm Erg. % Fatigue					
Endurance Grip (C)	● ⊙ ■	▣	■ ▣	●	+
Flexed Arm Hang	■	■ ▣	■ ▣	●	+
B. Abdominal					
Situps (raw)*	⊙	■		● ⊙	+
(%ile)*		■			
C. Lower Body					
Leg Erg. % Fatigue	●	▣			
D. Lactate					
Post Leg Erg.			●	●	
Post Crawl					
5. AVERAGE EXPRES				⊙	

* EXPRES Variables
(C) Combined Right & Left

LEGEND	Males	Females
Simple Correlations	●	■
Multiple Regressions	⊙	▣

A6.4. Discriminant Analysis

As an alternative to continuous predictive models, discriminant analysis was used to separate the groups of subjects by performance. In such cases, a required task performance score was first identified as the cut-off score. Subjects above this value were termed passers and those below this value were termed failers. The basis for selecting cut-off values for task performance was that provided by DPERA for these tasks. Thus, the land stretcher carry task required twenty minutes for completion, the low/high crawl ninety seconds, the entrenchment dig forty-five minutes, and the sea stretcher carry task ten minutes.

Having obtained the passing and failing groups, the discriminant analysis identified those parameters with scores that differed most between the two groups. These parameters were termed the discriminators. Based on the most significant discriminators, the predictability of passing and failing was then determined.

In no case could the appropriately selected discriminators separate passing and failing groups from the combined population with high reliability. The incidence of false negatives and false positives is shown in Table A11. A false negative is a subject placed in the failing group who actually was able to perform a task. Conversely, a false positive subject is one for whom fitness measurements would indicate passing but who actually failed that task. As can be seen in the Table A11. a disproportionate number of false positives and false negatives were produced by the discriminant analysis using EXPRES variables. In most cases over 30% was observed in the false negative category.

Discriminant analysis failed to reveal any EXPRES parameter or set of parameters which could be used to identify those subjects which would pass or fail. Of note is the high incidence of false positive results. This is a feature of the analysis since it is driven to predict failers as well as passers. As determined by this method, no fixed performance level in fitness tests predicted passing or failing in actual task performance.

A6.5. Empirical Model

The discriminant analysis produced an inordinate number of false negative predictions. Correlation models were unable to predict task performance in a continuous manner. Thus the idea of an empirical model was pursued to examine all of the passing subjects in individual tasks. By this method, a description of the population of passers was obtained. By examining the distribution of fitness scores, it was possible to describe the minimum expected score for each parameter of the passing population.

An insufficient number of females passed each task according to the criteria set by DPERA to enable subsequent statistical analysis. In addition, of those females passing, their EXPRES scores differed from their male counterparts. Thus, only data for males were used to

TABLE A11. Classification Results Obtained from the Discriminant Function Analysis of EXPRES Variables.

	Actual Task Performance		Predicted Performance[1] Correctly Classified		Incorrectly Classified	
	n	%	n	%	n	%
Land Stretcher Carry						
Pass	56	71	28	50	28	50
Fail	23	29	15	65	3	35
Total	79	100	43	54	31	46
Low-High Crawl						
Pass	53	71	34	64	19	36
Fail	27	29	18	67	9	33
Total	80	100	52	65	28	35
Entrenchment Dig						
Pass	24	71	11	46	13	54
Fail	56	29	37	66	19	34
Total	80	100	48	59	32	41
Sea Stretcher Carry						
Pass	35	90	22	63	13	37
Fail	4	10	4	100	0	100
Total	39	100	26	67	13	33

[1] The correctly classified passing and failing cells may be referred to as true positives and true negatives respectively. Incorrectly classified passing and failing cells may be termed false positives and negatives respectively.

determine the descriptive statistics for the passing sample. Means and standard deviations for every fitness parameter measured in this group was determined. Next, the value of each parameter representing the lowest 5% of the passing sample was determined as the minimum fitness score for the sample.

Using this method to identify passers predetermines the false negative incidence. In the worst case, 5% of subjects able to perform a task will be falsely identified as not being able to perform it. However, the number of false positives is indeterminant. That is, those subjects identified as being able to perform a task but not actually able to do so is not known.

A summary of these results is shown in Table A12. Each of these tasks is identified and the value of the minimum fitness score required to achieve passing is also indicated. To highlight the EXPRES data, Figure A1 represents the passers' EXPRES raw scores by task and Figure A2 shows the passing groups' percentile scores. Of note is the similarity among parameters for all tasks except the sea stretcher carry task. In this case, the fitness parameters were generally lower for all EXPRES measures.

To determine the appropriateness of the selected parameters for the empirical model, the correlations shown in Table A10. were also considered. These correlations showed that not all fitness parameters were important for every task. As a basis for establishing minimum standards, it was proposed that the parameters with a significant simple correlation to at least two tasks would be used to establish a minimum standard. These are indicated by asterisks (*) in Table A10.

The selection of values for the minimum physical fitness standard (MPFS) was determined for each identified fitness parameter individually. To do this, the task for which the highest simple correlation existed was used for the minimum value of the parameter. For example, combined maximum hand grip was identified as a component for the MPFS. It had a simple correlation to the sea stretcher carry task. Thus, the value of 75 kg was chosen from Table A12. as the required minimum standard. Had a simple correlation existed for the entrenchment dig for males, the MPFS would have to be set at 97 kg.

Using methods described, the standards shown in Table A13. were selected. A projection of the effect these standards would have on older males is shown in Figure A3. Interestingly, all four EXPRES parameters were chosen. The significant additions to EXPRES test items included measures of muscular strength and power. These were arm power and leg power as measured from ergometer tests and the ILM-6 lift (Table A13). All of these were required to describe the sea stretcher carry task, as might be expected by the nature of this activity.

Values used in the empirical model were raw score values. In the case of grip strength, percentile measurements were also significantly correlated with performance. However, the raw score, which also

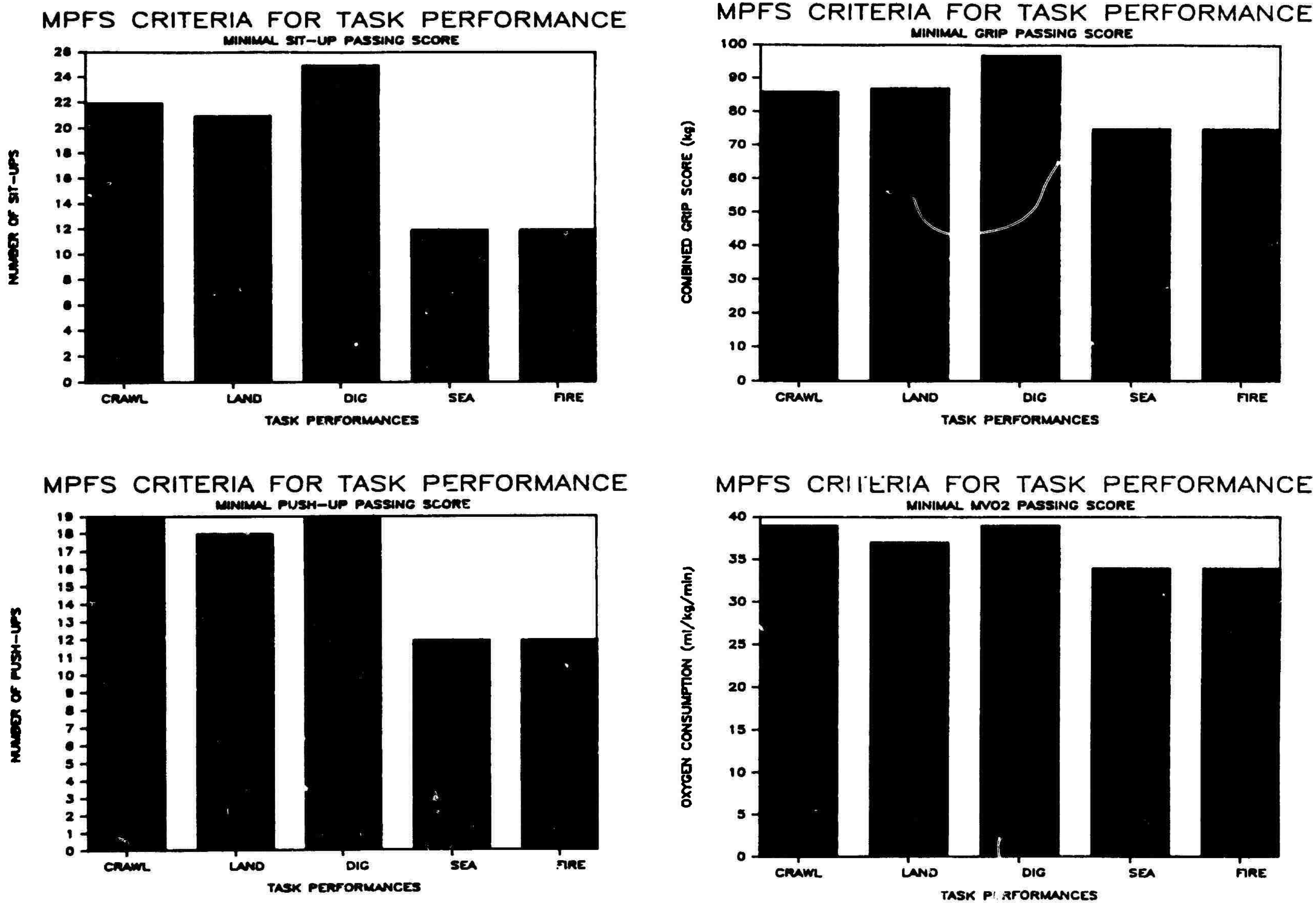


FIGURE A1. The 5th percentile values of EXPRES raw scores for the passing group of males calculated for each of the five task performances.

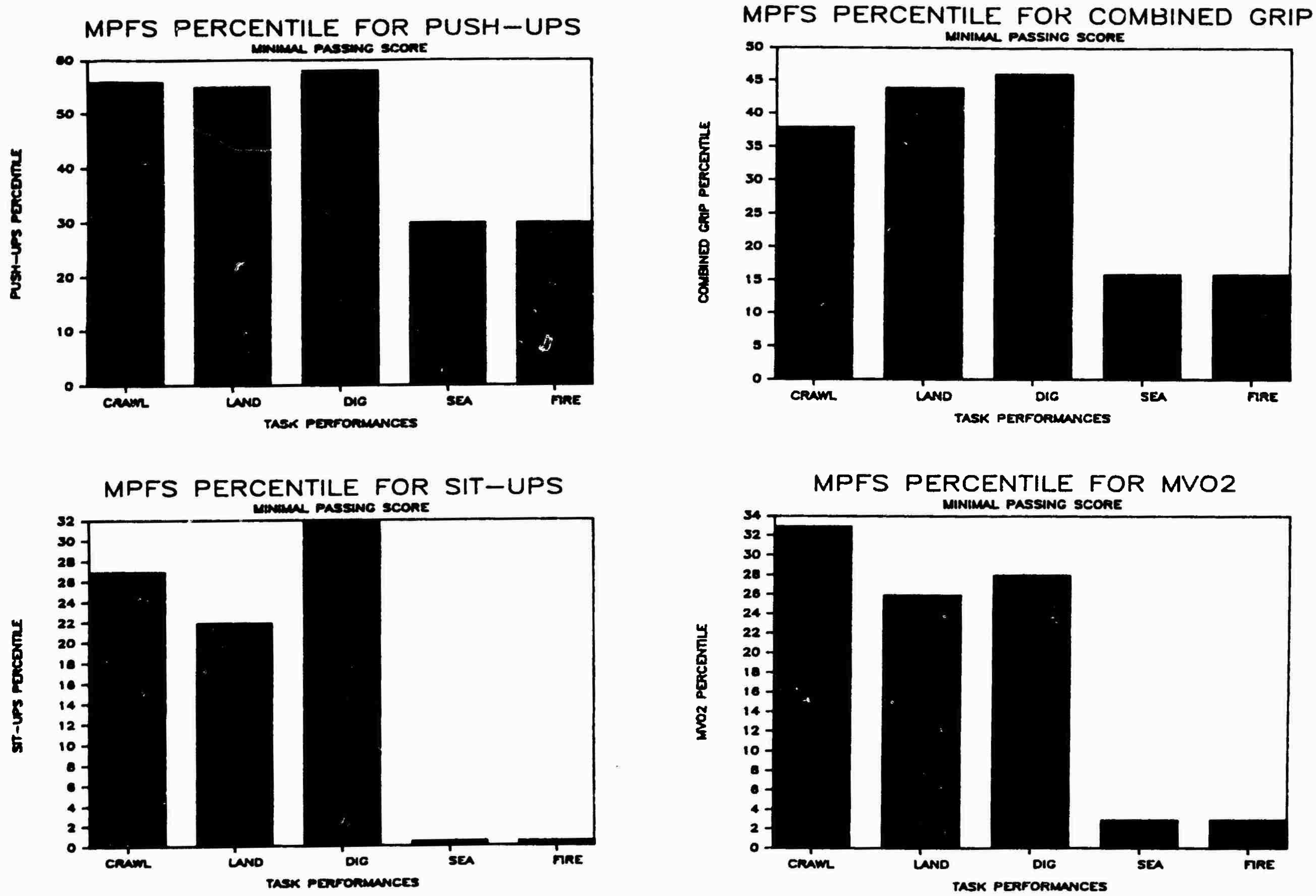


FIGURE A2. The 5th percentile values of EXPRES percentile scores for the passing group of males calculated for each of the five task performances.

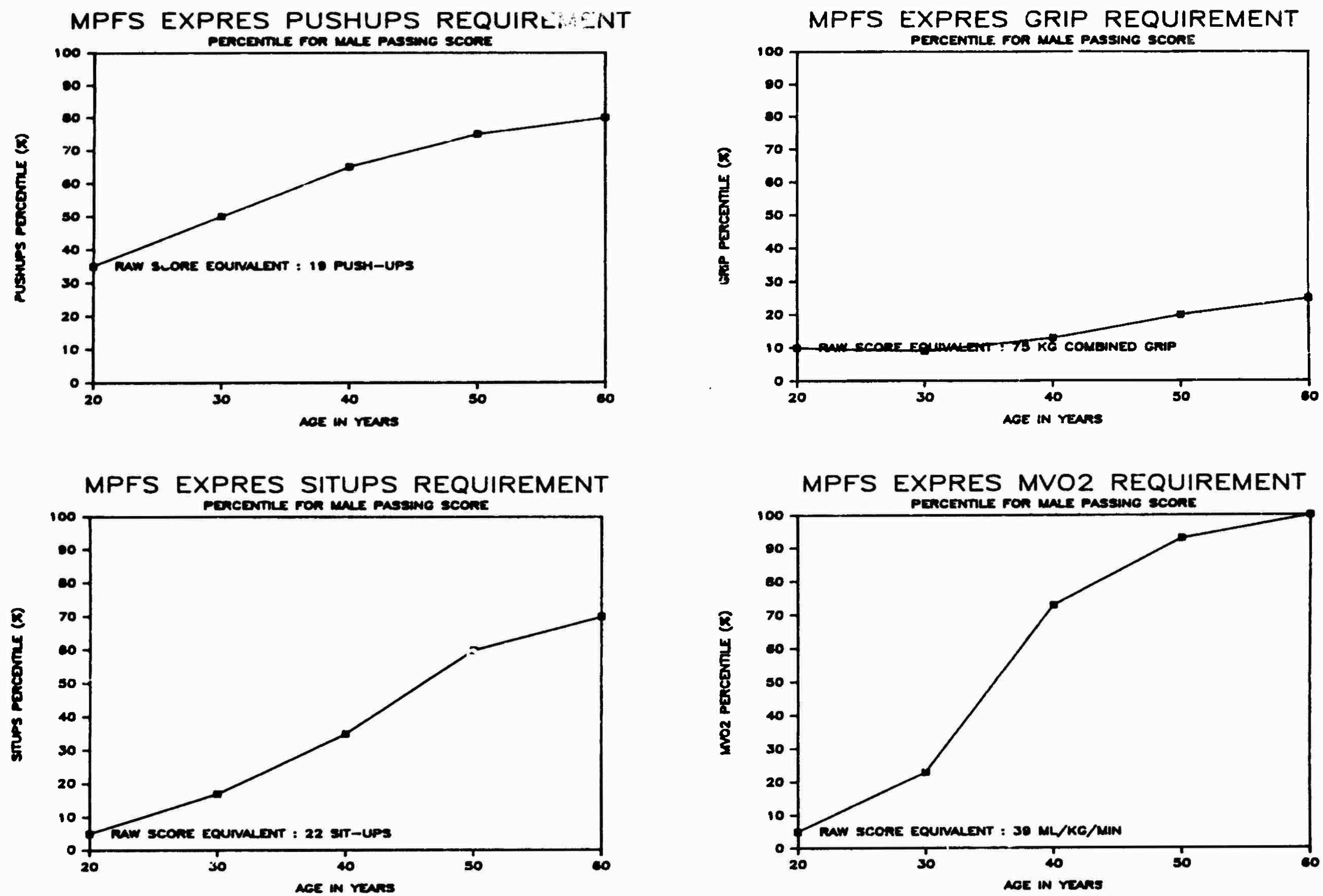


FIGURE A3. Implication of M.P.F.S. to age on male CF Personnel.

TABLE A12. Minimum Fitness Scores for Males Passing DPERA Criteria for Task Performance (5th Percentile).

FITNESS PARAMETERS	LAND EVACUATION	LOW HIGH CRAWL	ENTRENCHMENT DIG	SEA EVACUATION
1. ANTHROPOMETRY:				
Age	20	14	15	17
Height	146	145	165	144
Weight	[illegible]	59	66	61
% Body Fat	25	23	26	30
2. STRENGTH MEASURES:				
A. Upper Body				
Combined Max.				
Grip (raw)*	87	86	97	75
(%ile)*	44	38	46	16
Arm Power	1193	1195	1147	1204
B. Lower Body				
Leg Power	2462	2563	2562	2189
C. Total Body ILM 6'	36	37	37	33
3. AEROBIC CAPACITY:				
Step Test (raw)*	37	39	39	34
(%ile)*	26	33	28	3
Astrand-Rhyming	1.83	1.801	1.76	1.52
4. ANAEROBIC MEASURES:				
A. Upper Body				
Pushups (raw)*	18	19	19	12
(%ile)*	55	56	58	30
Armerg % Fatigue	49	49	50	--
Endurance Grip (C)	1.95	1.85	2.42	--
Flexed Arm Hang	28.2	30.6	30.2	19.6
B. Abdominal				
Situps (raw)*	21	22	25	14
(%ile)*	22	27	32	--
C. Lower Body				
Legerg % Fatigue	43	45	43	--

* EXPRES Variables
(C) Combined Left and Right

TABLE A13. Minimum Physical Fitness Standards Calculated at the Fifth Percentile.

* Combined Maximum Grip Strength (kg)	>	75
Arm Ergometer Power (kg.m/min)	>	1204
Leg Ergometer Power (kg.m/min)	>	2462
ILM Six Foot Lift (kg)	>	33
* Predicted MVO_2 (Step Test) (ml/kg)	>	39
* Push-ups (count)	>	19
Combined Endurance Grip (minutes)	>	1.95
Flexed Arm Hang (seconds)	>	19.6
* Sit-ups (count)	>	22
% Body Fat	<	23

correlated significantly, had higher regression coefficient. The latter score was therefore included in the model. However, the fact that EXPRES and other variables were not good predictors or discriminators would suggest that one cannot ensure performance on the seven common tasks. One can merely describe the passing group characteristics. It must be emphasized that these results are obtained from an empirical model of males only. It has the advantage of a fixed rate of false negative incidence, but an indeterminant rate of false positive incidence. Furthermore, female data are not adquately represented at this time.

One additional problem with this model is the skewed population distribution. By having a biased sample, there is an inherent weakness with the empirical model approach in that the accuracy of the 5th percentile cutoff point is questionable. This point can be highlighted by the fact that the failing group had lower 5th percentile values the same or in some cases higher than the passing group. If the population sample had been normally distributed, and the tasks less complex, one would expect better task validity. Seeing as the trained military personnel are more physically fit than normals, it would be appropriate to asses task performance on new recruits prior to training and in this way ensure as much as possible a homogeneous and normally distrubited sample. To adequately validate the suggested standards a large performance study is required. On the basis of the data currently available, reliable validation for the fitness standards proposed will require testing on approximately 200 subjects of each sex.

A6.6. Incremental Lifting Machine

A detailed analysis was performed on the kinetic data obtained from the Incremental Lifting Machine (ILM). This is fully documented in Section B7 and is briefly summarized here.

The ILM was instrumented to obtain speed and displacement data as a function of time for each lift performed on it. Using a previously established technique, the data were acquired using an IBM PC microcomputer and stored for subsequent analysis. This analysis identified 37 key variables in the form of time, displacement, speed, acceleration, force and power at various places of a lift cycle. With the large number of subjects in the Halifax and Kingston field studies, it was possible to reduce the number of variables to five "factors", each of which had a biomechanical significance in the lift sequence. Such an observation is novel and of particular scientific importance in describing tasks which have a significant lifting requirement.

ILM Factor Scores for the subjects of this study correlated with task performance no better than any other variable measured. This was a disappointing finding from the viewpoint of being able to predict performance in these representative tasks. However, the results do suggest that no significant lifting component was incorporated in the testing regimen. In view of other reports from DCIEM which indicate that up to 75% of common military tasks involve lifting, this finding suggests that the identified common tasks be reconsidered from this perspective.

A7. DISCUSSION

On the basis of this study, which can be considered a pilot project, certain conclusions can be drawn. Specifically, we have confirmed that the tasks included were very demanding physically. While performance was not well predicted by the fitness-related variables measured, we were able to identify some of the variables which had an important underlying role in task performance. In addition, based on these observations and with the inclusion of certain assumptions, we were able to identify those physical fitness variables which contributed most often to successful task performance. However, neither regession nor discriminant analysis of the data led to reliable predictions of performance. Therefore, an empirical model approach was applied in an effort to suggest inherent minimum scores for selected variables for men. This premise, that there is a minimum fitness score for task performance, was based on the knowledge that not less than twenty percent of the scores could be attributed to fitness level.

A7.1. EXPRES (Exercise Prescription) Protocol.

The present study was carried out for the purpose of developing minimum physical fitness standards (MPFS) which would be commensurate with satisfactory performance of selected military tasks requiring high physical demands; performance of such tasks in time of emergency is considered a realistic expectation of all military personnel. Accordingly, the contract examined the tasks selected, in terms of performance scores by subjects, and attempted to assess the relationship of such scores to accepted measurements (variables) of physical fitness; it was hoped these data and the relationships observed might provide the basis on which MPFS could be developed by the military. Since EXPRES currently is widely applied in the Canadian Forces and thus can provide a substantial data base, and since it includes test items generally regarded as relating closely to physical fitness, it became important also to evaluate the ability of EXPRES to predict performance of specific tasks.

EXPRES scores correlated reasonably with other laboratory fitness measurements in this study. As such, it appears to be a reasonable measure of general physical fitness. However, there are several limitations to this conclusion. The first relates to the well known relationship between body size and muscular strength. Cognizance of this fact is not completely taken into account in all EXPRES scores since no account is taken of body size differences for maximum grip strength.

In tests such as sit-ups and push-ups, the raw scores would tend to be normalized naturally for difference in muscle mass since the body mass (against which muscles must work in performing these tests) tends to bear a close relationship to the muscle doing the work. In other words, large people with greater mass, and presumably greater muscle mass, would face the same relative constraints in performing these tests as the smaller person with the smaller muscle mass. However, when pure muscle strength scores are the measure, the advantage clearly rests with the person with the greater pertinent muscle mass; the larger person should be capable of generating greater forces. The relationship between body size and maximum grip strength from the present study is shown in Figure A4. It would seem appropriate for the military to consider revision of EXPRES scores for strength to acknowledge this biological fact; normative data for EXPRES could be expressed in relation to body weight, surface area and some such appropriate variable; then from this, percentile scores could be developed which would permit comparison of individuals of varied physical size.

It must also be acknowledged that certain biological measurements are gender related. For example, the generally lower maximal oxygen uptake in women is determined in part by their smaller hearts (i.e., lower stroke volume) and lower hemoglobin level (i.e., smaller oxygen carrying capacity). Hence it would seem appropriate that either the MPFS standards should be established which take into account an equivalent percentile score, or a large data base of females should be sampled to develop task specific standards (as developed for male subjects in this study).

Since the task-related approach is so complex indeed as complex as humans themselves, the question remains of how best to develop MPFS, and how this in turn relates to EXPRES in its present form. Initially, one starts by accepting the basic tenet, supported by scientific evidence, that EXPRES is an acceptable index of general total body fitness. This is not to imply it measures all the important components of fitness, as discussed above, nor that it need not be revised and improved. Expansion of test items to include variables such as muscular strength and endurance, aerobic and anaerobic capacities, flexibility and others would be an option the Canadian Forces may wish to pursue. However the current study does not suggest that this approach would markedly improve prediction of performance, and moreover, the costs inherent in the added testing would be prohibitive.

A7.2. Fitness Content in the Common Military Tasks.

In most instances, tasks were evaluated according to objective, time-based criteria alone, in conjunction with specific, well-chosen muscle strength and endurance tests; as well, anaerobic and aerobic tests were compared to the task performance measures. However the results consistently showed that physical fitness attributes of the Armed Forces Personnel did not correlate to their task performances. Hence, at present it cannot be concluded that physcial attributes alone are the sole indicator of performance. This is not to say that physical fitness attributes are not important factors. This fact is borne out by the stepwise correlations which identified physical fitness variables which could explain a component of the performance score variance. Recognizing the complexity not only of the tasks, but of human beings themselves, it is not surprising that numerous possible variables other than physical fitness affect performance.

The aspects of the common tasks which were deemed to require a high fitness component were intense in nature, as indicated by average

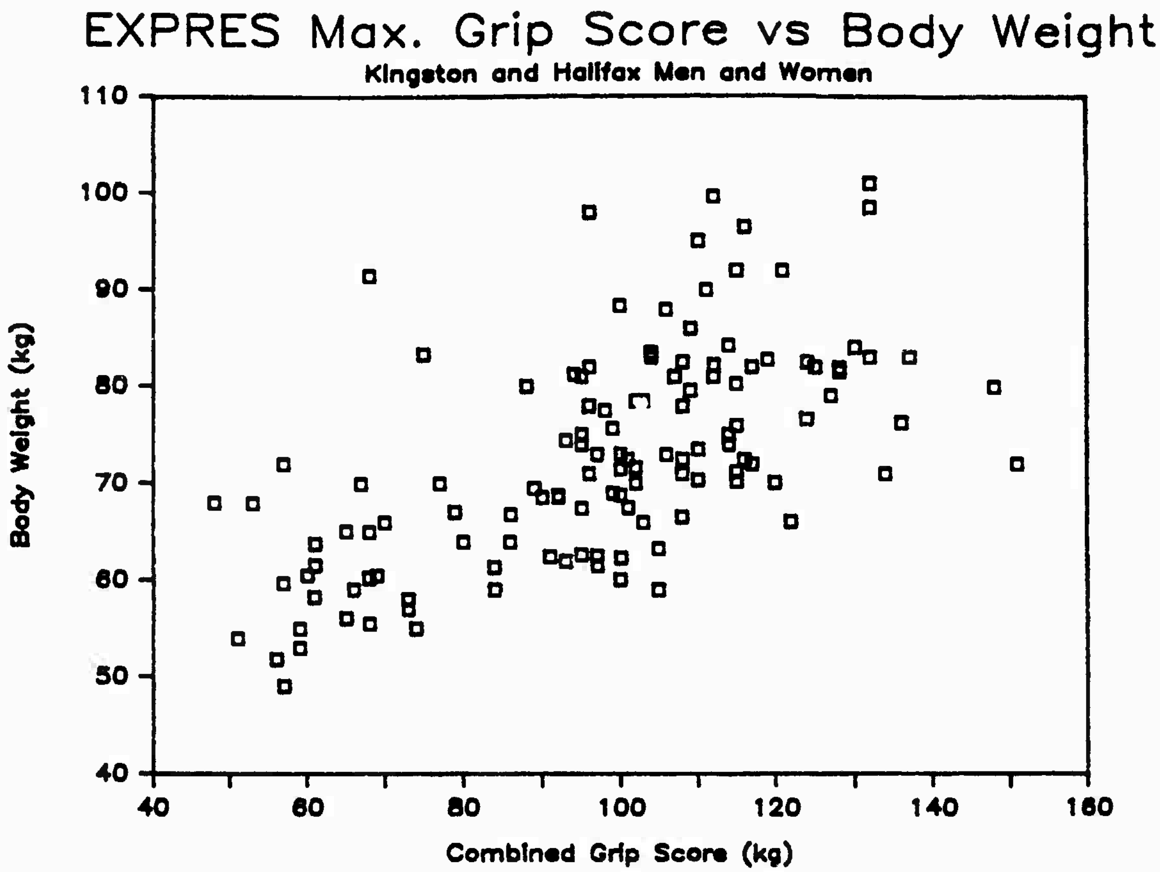


FIGURE A4. Effect of body weight on EXPRES combined maximum grip score.

heart rates in excess of 160 bpm. It would be our judgement that the design, intensity and duration of certain tasks could place subjects predisposed to cardiovascular problems at high risk. This has an implication on the establishment of MPFS, since, as individuals age, certain physiological capacities related to performance are reduced. Thus it is our belief that older groups should be asked to maintain a fitness percentile score rather than a fixed raw score.

A7.3. Predictabilty of Task Performance

EXPRES variables, whether used independently or in combination, correlated poorly to performance scores in the military tasks and, hence, could not predict performance. Futhermore, the addition of objective laboratory test items, including ILM lift variables likewise failed as important predictors of task performance. Finally, when EXPRES variables were used as indicators of whether subjects would pass or fail a given task, the results were not significant.

Certain tasks, namely fire fighting, could not be measured well on a pass/fail basis, as outlined by DPERA in the task requirements (see Appendix A). This was a result of the need for safety, difficulty of breathing CHEMOX, and due to inexperience in some cases. In other words, while technique was controlled in all tasks, their complexity often required considerable skill (low-high crawl) or experience (entrenchment dig). This made fitness assessments alone poor predictors of performance.

This is not to say that the study design was incorrect, nor the objectives pursued inappropriate. In our view, it serves to emphasize how difficult is the task of predicting performances which inevitably are dependent on a wide range of variables. Included are those inherent in the complexity of the task as well as the myriad of human variables such as motivation, problem solving skills and response to encouragement. Fitness variables alone are inadequate predictors.

A7.4. Proposed Minimum Physical Fitness Standards for Men

The minimum physical fitness standards shown in Table A13 represent the 5th percentile score for those males able to pass task performance criteria. By this method, the incidence of false negatives in men is fixed at five percent. However, unknown false positive incidence exists.

It must be emphasized that this model was developed from limited data and for men only. In particular was the presence of a sample pool with mean fitness scores in the upper half of the population. A large sample size with lower mean fitness scores is required to fully validate the model. Thus, the model should be regarded as a starting point. Its implementation must be done with full knowledge that evidence of performance capabilities drawn from it can easily be challenged in a court of law. First, the military tasks chosen were arbitrary tasks, and their performance standards were also arbitrarily established. Indeed, some standards were based on U.S. Marine standards, an acknowledged elite military corp, and the mass lift requirements of the tasks were equivalent to a heavier than average male rather than an average person. Second, the sample population on which the standard was based was skewed because of age, and experience at related tasks.

A7.5. Proposed Minimum Physical Fitness Standard For Women

The empirical model developed in Table A13 was based on males able to successfully complete the tasks. Results showed that in the performance of these tasks, different techniques were employed by women compared to men. Therefore physical requirements were also likely different. Empirical data for males most emphatically cannot be extrapolated to females. In several instances those women who passed specific tasks actually had EXPRES raw scores well below those of the empirically determined male EXPRES pass standard.

A7.6. Task Definition

Subjects emphasized that time for task completion was only but one of the important factors determining performance. Othe specific factors were identified such as safety for oneself and others, problem solving abilities with scope for flexibility of technique and stress management. General regard to psychological, sociological and moral aspects of the tasks was also expressed. These points suggest that in future task performance assessment, subjects should be granted a degree of freedom to choose a personal technique which allows a broader use of personal attributes, particularly since the present study clearly showed that strength related variables alone did not correlate well to performance. This was illustrated by personal comments from subjects such as the following:

- Personnel stated that they had never been trained nor tested on the low/high crawl, and that in addition to speed and safety, caution and quietness in combat situations were also critical variables.

- Regarding the overland stretcher carry, many subjects reported they would not execute the task in the field as designed for this study; rather, they would use their belt, shirt or the like to assist in load carriage (thus challenging one's problem solving abilities in this instance).

- To solve the entrenchment dig conditions, subjects stated that they would have cut trees, carried rock or piled sand to create the appropriate embankment in the alloted time (i.e., again using problem solving skills).

- At the fire-fighting station, Chiefs believed that the psychological stress was just as important as the physiological stress imposed upon Personnel in an actual fire situation.

- For the sea evacuation task, subjects reported that ship-board stretchers have ropes attached and that for their training sessions four people, rather than two, are employed for safety reasons.

A further concern was whether the criteria of the tasks themselves were appropriate. The minimum task criteria level were established prior to our contract. Our understanding is that the standards for pass/fail were largely arbitrary, and not based on empirical evidence. Indeed, the requirements to lift 80 kg is a gender related definition for task evaluation. As well some aspects of the task definitions (i.e., entrenchment dig and low/high crawl) were elitist as well as gender-related in that they were based on U.S. Marine minimum standards.

Although the mandate of our group was to identify the most physically demanding components and test those areas, it is necessary to point out that the physical requirements of the other tasks should not be overlooked. For example, it has been reported that the degree of sweating and heat stress while wearing NBCW clothing would favour women rather than men as women tend to be more tolerant to heat and cold environmental stressors. Other task requirements such as fine motor skills, and response to stress (i.e., shoot to live) tax physiological attributes as well and should not be excluded as unnecessary in a task approach measurement system.

An alternate approach to examining individual service personnel, either by task performance as in the present study, or under stress (e.g. combat) was undertaken by the U.S. Army where the effectiveness of an entire unit was examined. The specific purpose of the study was to examine the effect of women on combat unit performance. The first major study examined the performance of women in a 72 hour field exercise in which the percentage of women was varied up to thirty-five percent of the total personnel in combat support and combat service support units. The study concluded that the "proportion of women up to the percentage studied", had no effect on measures of unit performance in the field (U.S. Army Research Institute, 1977, p3-29). Other similar studies have reached the same conclusion (U.S. Army Research Institute, 1978, p.1-2).

The task related approach, whether by individual performance scores or by combat group scores would appear to have merit in identifying minimum physical fitness standards. However, there are inherent dangers in this design. First, fitness parameters cannot explain performance fully. Second, the sample population on which minimum task performance standards are set must be normally distributed and the test scores checked for reliability and validity. Third, task performance must be evaluated from a broader perspective, allowing some scope for individual differences in technique, as well as for problem solving skills. Once these corrections in approach have been undertaken, then an examination of the fitness profiles of the passing group could be used as a guideline for the total military population. This approach is consistent with recommendations contained in the recent report of the Parliamentary Subcommittee on Equality Rights, entitled "Equality for All", October 1985.

A8. CONCLUSIONS AND RECOMMENDATIONS

A8.1. EXPRES (EXercise PREScription) Protocol.

EXPRES is a reasonable measure of general physical fitness.

THEREFORE WE RECOMMEND THAT:

EXPRES continue to be developed and improved as a measure of physical fitness in the Canadian Forces and as a healthful motivator for C.F. Personnel.

A8.2. Fitness Content in the Common Military Tasks.

Not less than 20% of performance in the seven common tasks is accounted for by fitness components (Table A9).

THEREFORE WE RECOMMEND THAT:

Minimum fitness standards be established for the seven common tasks.

A8.3. Predictability of Task Performance.

It was not possible in the population sample to predict performance in the seven common tasks using fitness measures only.

THEREFORE WE RECOMMEND THAT:

To improve predictability of task performance, measurements of additional ergonomic variables specific to the activity must be combined with fitness measurements.

A8.4. Proposed Minimum Physical Fitness Standards for Men.

The fitness variables and scores listed in Table A13 reasonably represent the 5th percentile of the male population able to pass task performance criteria established for the seven common tasks.

THEREFORE WE RECOMMEND THAT:

If the establishment of a fixed task requirement is upheld as a reasonable requirement for C.F. Personnel performance, then these standards for men be adopted pending appropriate validation studies.

A8.5. Proposed Minimum Physical Fitness Standard for Women.

The fitness variables and scores listed in Table A13 do not represent the female population able to pass task performance criteria established for the seven common tasks.

THEREFORE WE RECOMMEND THAT:

If the establishment of a fixed task requirement is upheld as a reasonable requirement for C.F. Personnel performance, then standards similar to Table A13 be established for females with appropriate validation studies.

A8.6. Task Definition.

Task selection and specific performance criteria are not amenable to scientific analysis as undertaken in this study.

THEREFORE WE RECOMMEND THAT:

Specific common tasks be reviewed in terms of global objectives for these tasks. It is intended that techniques by which a global objective is attained be analysed in terms of specific tasks, equipment design and other ergonomic factors which may optimize the use of C.F. Personnel.

SECTION B.

DETAILED EXPERIMENTAL REPORTS

SECTION B1.

ANTHROPOMETRIC, EXPRES, AND LABORATORY TESTS

SECTION B1.

ANTHROPOMETRIC, EXPRES, AND LABORATORY TESTS

B1.1. Statement of Purpose

This section serves to describe the population studied from three perspectives: anthropometric measurement, including estimated body fat; EXPRES variables, as currently measured in the Canadian Forces; and Laboratory test items.

Since the over-riding purpose of the study was to provide information which might be of use in developing minimum physical fitness levels appropriate for satisfactory performance of military tasks, it was hoped variables from these tests would provide objective data for this purpose.

B1.2. Methodology

The detailed methodologies of the test batteries are presented in Appendix C; protocols for the various data measurements are summarized only below.

Physical Characteristics of Subjects

1. Height and Weight. Standing height and body mass were determined by means of Delto scale and adjustable height armature.

2. Percent Body Fat was determined according to the method of Parizkova (1961), predicted from the measurement of body fat at four sites on the body: triceps, subscapular, suprailiac and umbilical, all measured on the right side of the body.

Physical Fitness of Subjects, as Determined by EXPRES

EXPRES is the Standard Canadian Forces Test of Fitness, with sex and age adjusted norms (reader is referred to the EXPRES Handbook). Four of the test items are recorded in this section:

1. predicted maximal oxygen consumption as determined by a step test
2. pushups (note: female subjects perform modified pushups - see Handbook)
3. situps
4. combined grip score as measured by a Hand-Grip Dynamometer.

Laboratory Test Items.

The following six items were included in this test battery:

1. Wingate Power Test: 30 second, supra-maximal leg ergometer test for predicting anaerobic capacity and leg power.

2. Upper Body Power Test: 30 second, supra maximal arm ergometer test for predicting upper body and arm power.

3. Flexed Arm Hang Test: suspended off the ground, grasping a horizontal bar, subjects raised themselves to eye level with the bar, and using the arms and upper body musculature, remained suspended for as long as possible; this time was recorded to the nearest second.

4. Endurance Hand Grip Test: squeeze hand grip dynamometer to 20 kg and hold; time of hold was recorded to the nearest second.

5. ILM Test: lift weights of progressively increasing mass to maximal to a height of 6 ft.; with the aid of an on-line microprocessor computer, 37 variables entailed in the lift were derived and recorded (see section B7 for details).

6. Post-Exercise maximal blood lactate determination: 3-5 minutes following completion of the Wingate Power test a 2-3 ml sample of venous blood was withdrawn from an anticubital vein of the arm.

B1.3. Results

Table B1.1 presents mean values, standard deviation (± s.d.) and range for height, body mass and percent body fat of both the male and female Forces Personnel tested at Kingston and in Halifax; these persons formed the subject pool in this study.

In all, 132 subjects were tested, 87 of whom were in the Kingston groups. 32 subjects were women. The number of subjects varied somewhat from task to task because of missing data on some of the fitness variables, or use of non-military personnel to create a stretcher-carry pairing. Hereafter, the subject pool is reported within each table. Mean ages of the men approximated 28.2 years and for the women about 26 years; the ages ranged from 19 to 51 years. Values for the physical dimensions and estimated body fat fall within the range of expected normal values.

In Table B1.2, EXPRES scores are tabulated in terms of mean percentile values for each of the four test items as well as a mean percentage of the combined test item scores. Only for the Halifax men were any of the mean values below the fiftieth percentile level; for this group, mean sit-up score was 44 (±30.1). This along with the relatively low score in predicted maximal oxygen uptake (MVO2) accounted mostly for their lower mean combined score of 57.4 %; this value was below that of the Kingston subjects (74.6 ± 13.3 %) and was substantially lower than the 80.2 % for the women's combined percentile score. Accepting EXPRES

TABLE B1.1. Summary Data of Anthropometric Variables of Population: Height, Body Mass, Percent Body Fat and Age of Subjects[1].

		Height (cm)	Weight (cm)	Body Fat (%)	Age (yrs.)
Kingston					
Females	Mean	164.8	62.9	24.7	25.6
(n=19)	s.d.	4.3	10.4	6.3	4.7
	Range	(155-173)	(49-92)	(14-38)	(21-37)
Males	Mean	173.5	77.9	16.3	27.6
(n=61)	s.d.	15.9	15.1	4.4	8.3
	Range	(66-196)	(57-167)	(6-25)	(19-51)
Halifax					
Females	Mean	165.7	61.7	27.8	26.9
(n=11)	s.d.	5.9	5.8	4.9	4.8
	Range	(154-173)	(52-72)	(22-37)	(22-37)
Males	Mean	173.9	76.3	19.2	29.3
(n=31)	s.d.	17.7	9.3	4.9	7.4
	Range	(83-188)	(60-98)	(9-31)	(21-46)

[1] The data are similar to that shown in Table A1 and are presented here for convenience of the reader.

TABLE B1.2. EXPRES Scores of Subjects, Age-adjusted, (in Percentile Rankings ± s.d. and Range in Brackets), and Overall Fitness Ranking (Right-hand Column).

		Pushups (%ile)	Situps (%ile)	Combined Hand Grip (%ile)	Predicted Maximal O Consumption (%ile)	Overall EXPRES Rating (%ile)
Kingston						
Females	Mean	91.3	79.0	80.3	65.8	79.1
(n=19)	s.d.	16.3	24.6	21.4	30.2	15.3
	Range	(31-100)	(15-100)	(30-100)	(7-97)	(40-98)
Males	Mean	84.1	68.2	75.0	71.0	74.6
(n=61)	s.d.	16.6	27.6	20.5	26.2	13.3
	Range	(30-100)	(5-100)	(8-100)	(3-100)	(39-97)
Halifax						
Females	Mean	94.3	77.2	81.9	76.7	82.5
(n=11)	s.d.	6.9	25.8	13.4	16.2	8.1
	Range	(78-100)	(20-100)	(63-100)	(45-97)	(65-92)
Males	Mean	71.2	44.0	62.9	52.6	57.4
(n=33)	s.d.	24.3	30.1	27.8	29.3	18.7
	Range	(18-99)	(4-97)	(3-100)	(2-95)	(21-93)

TABLE B1.3A. Summary Data of Performance Scores on Laboratory Tests Involving Anaerobic Power.

A. Anaerobic Power Tests

		Upper Body (Arm) Power (kgm/min.)	Upper Body (Arm) Fatigue (%)	Lower Body (Leg) Power (kgm/min.)	Lower Body (Leg) Fatigue (%)	Post Exercise Blood Lactate (mg%)
Kingston						
Female	Mean	842.1	61.3	2118.2	58.7	58.3
(n=20)	s.d.	161.3	8.3	273.6	9.4	10.6
	Range	(504-1190)	(46-75)	(1663-2671)	(44-86)	(41-82)
Male	Mean	1557.4	60.9	3220.5	61.6	73.5
(n=64)	s.d.	290.5	7.4	478.7	40.5	14.1
	Range	(1008-1872)	(47-83)	(1991-4147)	(36-90)	(27-108)
Halifax						
Female	Mean	802.4	57.5	2087.9	53.4	68.7
(n=10)	s.d.	94.1	20.0	211.1	20.0	23.3
	Range	(655-965)	(50-80)	(1663-2340)	(45-88)	(60-85)
Male	Mean	1526.9	57.7	2993.8	55.5	73.0
(n=33)	s.d.	193.8	10.6	481.3	12.1	12.6
	Range	(1145-1896)	(35-79)	(2143-4406)	(46-89)	(49-106)

TABLE B1.3B. Summary Data of Performance Scores on Endurance Tests.

		B. Muscle Endurance Tests			
		Endurance Grip			Flexed Arm
		Right Hand (sec.)	Left Hand (sec.)	Combined (sec.)	Hang (sec.)
Kingston					
Female	Mean	55.1	44.3	99.4	25.5
(n=21)	s.d.	33.3	28.9	55.3	18.2
	Range	(18-132)	(0-102)	(24-228)	(0-69)
Male	Mean	139.9	109.2	249.1	42.3
(n=65)	s.d.	47.0	43.2	82.6	12.3
	Range	(48-258)	(36-258)	(84-516)	(22-76)
Halifax					
Female	Mean	47.4	39.0	86.4	23.0
(n=11)	s.d.	29.5	22.0	48.8	14.3
	Range	(16-111)	(16-81)	(36-192)	(2-50)
Male	Mean	124.6	101.4	226.0	43.1
(n=34)	s.d.	55.2	41.8	93.1	13.9
	Range	(60-360)	(40-240)	(101-600)	(10-61)

TABLE B1.3C. Summary Data of Performance Scores on Aerobic Tests and ILM Lift.

		Aerobic Tasks		ILM 6' Lift
		Predicted MVO2 (l/min.)	Predicted MVO2 (ml/kg/min.)	(kg)
Kingston				
Female	Mean	2.04	32.3	27.2
(n=21)	s.d.	0.36	5.3	6.7
	Range	(1.4-3.0)	(21-40)	(19-51)
Male	Mean	2.85	37.3	49.6
(n=65)	s.d.	0.63	9.3	8.0
	Range	(1.9-4.4)	(13-61)	(24-69)
Halifax				
Female	Mean	2.40	39.5	24.7
(n=11)	s.d.	0.29	7.0	3.1
	Range	(1.9-2.8)	(28-49)	(19-30)
Male	Mean	2.72	35.7	49.7
(n=34)	s.d.	0.71	9.0	10.1
	Range	(1.6-4.2)	(20-59)	(33-85)

scores as an expression of fitness level, these Forces Personnel would rank above average and this was particularly apparent in the females tested.

Mean values for items included in the Laboratory Tests are presented in Table B1.3A-C. Both for convenience, and because of the general nature of the test items, they have been grouped into: A. Anaerobic Power Tests; B. Muscle Endurance Tests; and C. Aerobic and ILM Lifting Tests. For the upper body test (Table B1.3A) which entailed use of the arm ergometer, results are expressed as total power (kgm/min.); also a fatigue index (% Fatigue) was determined by expressing the work rate being performed at the end of the test as a percent of peak power output achieved early in the test. Consistent with the greater upper body strength of the men, their power output was greater than for the women. No difference was observed between groups (Kingston vs. Halifax), nor was there a difference between genders in % fatigue. Similar trends were observed in the lower body power test, although total power output was higher for both females and males because of the greater muscle mass utilized in the test. These tests, being short duration high power activities, are thought of as "anaerobic" in nature; confirmation of this is provided by the post-exercise lactate values. All would suggest high anaerobic involvement and these values were only marginally higher in men.

Table B1.3B presents mean values for muscle "endurance" tests in which sustained activity was required and duration was the principal variable. Marked differences between men and women were evident for each test item, however the wide ranges in values in both groups caused a marked degree of overlap between men and women. No normative data for these measures is at hand.

The Aerobic tasks entailed the prediction of maximal oxygen uptake from a sub-maximal leg ergometer test. Mean values for this test and those for maximal ILM isoinertial lift to 6' are shown in Table B1.3C. In the men, maximal oxygen uptake was 37.3 ± 9.3 ml/kg/min. for the Kingston group and 35.7 ± 9.0 ml/kg/min. for the Halifax men would place them about the 50th percentile for Canadians (est. 36-39 for this age group - Canadian Fitness Survey - 1984) using the step test as the predictive device. In contrast, the overall mean for women Service Personnel fell close to the 75 percentile, the Halifax group being particularily high compared to Canadian norms. Woth noting is that these values predicted from a cycling task, were below those predicted by EXPRES which utilized a stepping task; the difference in methods presumably accounts for some of the difference in predicted values.

The ILM scores for both males and females were notably higher than previously reported in a Queen's University study and D.C.I.E.M. data on Military Personnel. The mean for women was 27.2 ± 6.7 kg. for Kingston subjects, and 24.7 ± 3.1 for Halifax subjects. The aformentioned studies had ILM scores of 23.8 ± 3.7 kg and 21.5 ± 2.2 kg respectively. Interestingly, the magnitude of difference was approximately equal to the smaller mass increments used in the current ILM protocol (see Appendix G). For men, this study had a mean for both groups of 49.6 ± 9.1 kg whereas the Queen's study reported means of 46.6 ± 8.6 kg. and D.C.I.E.M. means were 40.0 ± 7.2 kg ($p < .01$). These findings could be attributed to the overall strength performance of these subjects which was skewed to the upper percentile scores. An additional reason for differences may have been related to instrumentation. The low pass filter, used on the displacement/velocity data, may have been too severe and failed trials went undetected. This possible cause will undergo verification in a subsequent study.

B1.4. Interpretation

As indicated above, when EXPRES values of the present population are compared with the extensive data available on the Canadian Forces, on a percentile age- and sex-related basis, our subjects ranked high but for two exceptions. Halifax men were marginally low in sit-up scores (44%); and relative to others in this study this group had the lowest predicted MVO2 (52.6%). On the whole, these data indicate a fitness level, as implied from EXPRES, that was well above fellow service personnel; this was particularly so for both women groups. This implies a measure of selectivity in the process of choosing "volunteer" test subjects, and the resultant narrower data range observed was expected. This had implications for data analysis, particularly for statistics entailing discriminant analysis and prediction of task performance (discussed later).

The laboratory test items were included to provide further objective data against which task performance could be compared, to provide variables which might serve as valid predictions of performance, and also to permit comparison with EXPRES variables. It was postulated these data might provide the quantitative basis, in terms of physical fitness related measurements, for developing minimum standards required to satisfactorily complete the typical military tasks under study. Discussion along these lines is included in relation to each task in the ensuing sections.

B1.5. Conclusions

These data are considered descriptive and provide the general characteristics of the 132 subjects (100 males and 32 females) in the studies. The data indicate:

1. Subjects had normal body fat in relation to sex and age.

2. EXPRES scores, with mean values relative to age and sex in the main were well above the 50th percentile, suggesting a physical fitness level well above the mean for Canadian Forces.

3. The laboratory test items included may prove to be significant variables of value in determining physical standards of fitness essential for satisfactory performances of selected military tasks. This aspect is considered in detail below.

SECTION B2.

LAND STRETCHER CARRY TASK

SECTION B2.

LAND STRETCHER CARRY TASK

B2.1. Statement of the Problem.

Casualty evacuation (overland) was simulated by a stretcher carrying task. In combat, this involves two people; however, for the present simulation only one of these was a Forces Personnel (i.e., the subject being studied), while the other person was a member of the testing team (i.e., a "super subject" experienced in carrying, therefore not rate-limiting for the test subject). The cinder, quarter-mile track at CFB Kingston provided the 'terrain' for the simulation.

Performance criteria: Two person team, using a stretcher, to evacuate a normal person (80 kg) across a rough terrain a distance of 1 km within 20 minutes.

B2.2. Summary of the Literature.

Several studies have examined the physical effects of load-carrying overland. Regarding the present task, which consisted of stretcher evacuation supporting 80 kg, the majority of these data would indicate that the carriage of similar loads would elicit a submaximal response classified as moderate work (Astrand & Rohdal, 1977), and that two intensity factors influence the scores. First, the mechanics of stretcher carry, maintaining the load at the midline of the body (in the sagital plane) with minimal sway and counter-motion has been shown to reduce energy expenditures significantly (Soule et al., 1978). Second, local fatigue in the forearms and hands has been shown to reduce grip strength (Kearney & Stull, 1981). Lind and McNicol (1968) determined that load-carrying by hand in excess of 10 kg eventually led to fatigue; specifically, carrying a stretcher loaded to 82 kg overland (by 2 persons) at a speed of 2 m.p.h., the subjects experienced volitional fatigue on average by 3 min. 10 sec., with their physiological response being moderate at this point (i.e., heart rate 145 beats/minute; mean blood pressure 143mm Hg).

These data have been confirmed by other investigators (Evans et al., 1983; Gordon et al., 1983) performing a series of load carrying tasks using a backpack; these latter studies concluded that the time to exhaustion varied with the weight of the load. However, carrying a load one-half the body weight elicited a heavy physiological response of 70% of the subject's maximal aerobic capacity (Gordon et al., 1983); as well, such a load can only be supported for one to two minutes when carried by hand (Evans et al., 1983). On the other hand, Soule et al. (1978) found that both the balancing of the load as well as the speed of carriage influenced their subjects' physiological responses. Specifically, with balanced load-carrying, increasing the speed of carriage from 3.2 to 6.4 km/hr. doubled energy expenditures. Finally, in load-carrying by hand local muscle fatigue has been found to influence subjects' carry ability.

Gordon et al. (1983) reported that EMG activity in selected muscle groups increased with greater load carriage. Kearney and Stull (1981) in a study of grip strength reported similar findings; also, with the onset of fatigue, the rate of force development was affected during subsequent tests (i.e., it decreased).

B2.3. Methodology.

The purpose of this task was to carry a stretcher loaded to 80 kg a distance of one kilometre as quickly as possible. This was a simulation of the evacuation of injured personnel. Details of this test protocol are provided in Appendix C.

The stretcher carry was performed at the 400 m track, C.F.B. Kingston. Pylons were positioned 50 m apart around the course to estimate the distance (to the nearest 10 m) between set-downs. The subject's starting position at the front or back of the stretcher was randomly assigned. The subject walked at a brisk, self-determined pace during the carry; running was not allowed. The frequency and duration of the rest periods were left to the discretion of the subject. As well, the subject was permitted to switch to the other end of the stretcher at any point in the carry. The distance remaining was announced periodically, and the task ended after 2.5 laps of the track had been completed.

A "Super Subject" who was a member of the investigating team was paired with each test subject, and followed the pace established by the service person being tested. If he experienced fatigue another member of the testing team would either assist in the carry or switch entirely (but only during one of the subjects rest stops). Shoulder straps were made available to these persons; these proved useful during the initial stages of the task particularly when the rest stops were spaced farther apart. The variables recorded were:

1) time to first setdown;
2) distance to first set-down;
3) intermediate heart rates (by 10 second pulse count) when the subject set the stretcher down for a short break;
4) final heart rate; and
5) final time to completion of the task.

B2.4. Results.

The time to completion of this evacuation task was 43.0 ± 24.1 minutes for the female subjects, 15.7 ± 4.4 minutes for the males (see Table B2.1). As well, the time to first set down (rest) was shorter for the females and, overall, the females seemed to require a greater number of setdowns in completing the task. The physiological stress as measured by heart rate response is indicated in Table B2.2; neither mean values nor their range differed betweeen men and women and the mean terminal heart rate of 169 bpm indicated high intensity work.

TABLE B2.1. Summary of Results - Land Stretcher Carry

SUBJECTS	FIRST REST TIME (min)	FIRST REST DISTANCE (m)	TOTAL TIME (min)	SUBJECTS ACHIEVING CRITERION[1] NO.	SUBJECTS ACHIEVING CRITERION[1] %
FEMALES (n=21)					
Mean	1.5	109.3	43.0	2	(11%)
S.D.(+/-)	0.6	43.9	24.1		
Range	0.7-3.0	40-190	16.6-110.0		
MALES (n=65)					
Mean	3.1	292.3	15.7	54	(88%)
S.D.(+/-)	1.4	136.7	4.4		
Range	0.9-8.4	80-800	8.0-26.8		

[1] Pass Criterion: 20 minutes to complete 1000 m carry.

TABLE B2.2. Heart Rate Response During Land Stretcher Carry

SUBJECTS		HEART RATE RESPONSE (BEATS/MINUTE) INTERMEDIATE	FINAL
FEMALES (n=18)			
	Mean	169.0	169.2
	S.D.(+/-)	10.9	14.1
	Range	150-192	132-198
MALES (N=64)			
	Mean	168.0	169.0
	S.D.(+/-)	10.8	16.3
	Range	132-192	140-222

Univariant analysis showed low correlation relationship between individual EXPRES variables and test performance; however the predictive value of EXPRES variables when combined was improved. This is indicated in Table B2.3 which shows the results of the stepwise multiple regression analysis. However, the derived regression equation was significant in the males only; presumably, this is attributable in part at least to the comparatively small "n" in the female group. Classification results of the discriminant analysis comparing the groups of passers and failers (the criterion being completion of the task within 20 minutes), with EXPRES percentile scores as discriminating variables are given in Table B2.4. The discriminant function, calculated to maximize Wilk's lambda (λ=0.98) was not significant (χ^2=1.54, p=0.82). Of the passers (n=56), only 50% were classified correctly, while of the fails (n=23) 65% were correctly classified. In total, in only 54% of the subjects were the EXPRES variables found to be of value as reliable discriminators.

Finally, Table B2.5 presents the stepwise regression analysis incorporating both the EXPRES variables (Table B2.3) and laboratory test variables. For the women, the only variables selected having a significant relationship to the Land Stretcher Carry task were combined endurance grip, flexed arm hang and % fatigue for leg ergometer, all of which were contained in the laboratory measurements. Though significant (p=0.03) this accounted for only about half the variance in the measure (R^2=0.49). For the men, combined endurance grip (age adjusted), and % fatigue leg ergometer, both variables which were selected for the women as well, were significant variables. Again, although the derived equation was significant (p=0.004) the correlation was low (r=0.32) and accordingly, only 11% of the variance was accounted for in the equation (R^2=0.11).

B2.5. Interpretation.

The aspect of the task that was deemed most difficult was maintaining the hand grip on the stretcher. Lind and McNicol (1968), studying the effect of holding a 20 kg mass in each hand (40 kg in total), found that all subjects could grip the 20 kg mass for 2.5 minutes but some of their subjects were reported close to fatigue. These values are in reasonable agreement with those from the present study with the time to first set-down being 3.1 minutes for men and 1.5 minutes for women.

With strength-endurance activities, Lind and McNicol (1967) reported that with muscular fatigue, at least 40 minutes were required to attain 75% recovery of maximal muscular force. In the current study, this was exemplified by the fact that all subjects tended to set the stretcher down more frequently as the task continued.

Lind and McNicol (1968) also found heart rates of 145 bpm for subjects carrying 82 kg at a speed of 3.2 kph over level terrain. The higher heart rates found in our study are attributed to the faster walking speed, and hence greater work rate. This is in agreement with the earlier work of Soule et al. (1978) who observed that even with load carrying using backpacks (a more efficient load-carrying technique) loads of 50% body weight elicited average heart rates of 163 bpm, which

TABLE B2.3. Stepwise Multiple Regression Analysis: Land Stretcher Carry Task Performance[1] by Sex as Function of EXPRES.

Sex	Predictors	B	Beta	R	R^2	F	P
Females	Constant	-256.27	0				.259
(n=18)	Pushup	2.07	0.35				.139
	Height	-1.04	-0.39				.103
				0.502	0.252	2.52	.114
Males	Constant	50.56	0				<.001
(n=61)	Height	-0.12	-0.45				.005
	Weight	-0.13	-0.27				.002
	Situp	-0.11	-0.27				.040
				0.446	0.199	4.48	.007

[1] Pass Criteria: 20 minutes to complete stretcher carry task.

TABLE B2.4. Discriminant Function of EXPRES Variables for Land Stretcher Carry.

	Actual Task Performance		Predicted Performance: Correctly Classified		Predicted Performance: Incorrectly Classified	
	n	%	n	%	n	%
Pass	56	71	28	50	28	50
			(True Positives)		(False Positives)	
Fail	23	29	15	65	3	35
			(True Negatives)		(False Negatives)	
Total	79	100	43	54	31	46

TABLE B2.5. Stepwise Multiple Regression Analysis: Land Evacuation Task Performance[1] by Sex as a Function of EXPRES plus Laboratory Test Items.

Females

Predictive Variables	B	SE B	beta	R	R^2	F	P
Combined Endur. Grip	-0.189	0.053	-0.49			12.90	.001
Flexed Arm	-0.51	0.17	-0.24			9.04	.006
Leg Erg Fatigue	-0.86	0.38	-0.32			5.14	.03
Constant	123.84	24.04				26.55	<.001
(equation)				0.69	0.49	8.60	<.001

Males

Predictive Variables	B	SE B	beta	R	R^2	F	P
Combined End Grip	-0.01	.004	-0.26			7.28	.008
Leg Ergometer Fa .gue	-0.09	.04	-0.22			5.21	.02
Constant	23.77	2.70				77.54	<.001
(equation)				0.32	0.11	5.90	.004

[1] Pass Criteria: 20 minutes to complete stretcher carry task.

corresponded to a mean workload equivalent to 67% of their maximal oxygen consumption. In the light of these data, and other reports from the literature (cited by Astrand & Rodahl, 1977), the present task must be classed as heavy work since the load was 51% of the body weight for males, 65% of body weight for females (Gordon et al., 1983).

Based on the discriminant function analysis, only 54% of the total sample was correctly classified. Obviously this does not justify use of EXPRES as a predictor of pass/fail scores. Similarly there were no strong predictors from the two regression analyses, the stepwise regression with EXPRES (Table B2.3) and the stepwise regression with all variables (Table B2.5). Despite the fact that the variables studied cannot predict performance, they do indicate that physical fitness scores are important. It should be pointed out that the small number of females studied weaken any argument that 50% of the variance can be explained for women.

B2.6. Conclusions.

1) This task demands an intensely high work rate and is without question a difficult task.

2) EXPRES variables were not found to be reliable discriminators of an individual's performance of this task.

3) The problem of small sample sizes within subgroups made it very difficult to place standards on this task (because of skewed population samples, age and sex factors).

SECTION B3.

LOW-HIGH CRAWL TASK

SECTION B3.

LOW-HIGH CRAWL TASK

B3.1. Statement of the Problem.

This task was a simulation of Forces Personnel in combat pinned down by enemy fire, moving accordingly, employing the low crawl and high crawl techniques. The task was conducted at CFB Kingston on the grassy infield of the quarter-mile running track.

Performance Criteria:

Low and high crawl: The soldier does the low crawl (all body parts close to the ground) for 30 m, turns 180 degrees and does the high crawl (on hands and knees) for 45 m. Pass criterion is 90 s. for completion of this task.

B3.2. Summary of Literature.

Published research specifically quantifying the physical demands of the low-high crawl does not exist. The task was chosen from the list of seven common tasks (as defined by DPERA) and was included in the present MPFS battery of tests for several reasons. First, preliminary data from pilot work with 19 military personnel (12 men & 7 women) indicated the task was demanding, eliciting an average heart rate for the group of 191 beats per minute (range of 152 to 216 beats/min, see Appendix D); this suggested the task entailed a high measure of physical fitness. Second, the task itself required motor co-ordination, and the use of large muscle groups of the body. In this task, against time, the individual while prone moves forward as fast as possible while holding a rifle (a mechanically disadvantaged position), and subsequently returns by crawling on hands and knees. These are skills which cannot be accomplished without the incorporation of the body's major muscle groups. On this basis the low-high crawl was judged an appropriate task to include in the present study designed to assess the relationship of physical fitness to performance of tasks thought to require high levels of fitness.

B3.3. Methodology.

On the testing site, three pylons were placed in a straight line (see Appendix C), the first two 15 m apart, and the third 30 m from the second. The second pylon was considered the "start" pylon.

The subject started in a prone position with both hands on the rifle. On the command "go" the subject began a leopard crawl (low crawl) towards a pylon 30 m in front. At 30 m the time was recorded, and the subject rose to the hands-and-knees position, pivoted 180 degrees and crawled (high crawl) 45 m to the finish. During the high crawl, the gun was slung over the back and secured; occasionally some subjects chose to drag the gun in one hand. At the finish the time was recorded and a 10 s heart rate taken. A venous blood sample was also taken 5 minutes after the completion of the task with the subject resting quietly, supine.

For a majority of the subjects, heart rate was monitored throughout the testing using telementry. The electrode positions on the skin were cleaned with a mild abrasive and alcohol, the electrodes applied with adhesive, and a transmitter positioned on the subject's waist prior to testing. The variables recorded were:

1) time to complete low crawl;
2) time to complete high crawl;
3) total time;
4) final heart rate; and
5) final lactate level.

B3.4. Results.

As shown in Table B3.1, the time to complete the low-high crawl for female subjects was approximately 149 ± 69 seconds, and for males 77 ± 15 seconds, a time ratio of about 2:1. As well, in both genders this time ratio for the low and high crawl components were about equal as the females required approximately twice the time taken by the males for each test component. Using 90 s as the pass criterion, no females reached this standard while all but 3 of 61 males were successful. In this regard, it was noted that although all subjects showed poor crawl technique, particularly in the leopard crawl, the females appeared to remain lower to the ground than the males while doing this initial phase of the task. This could be expected to increase their required time to complete the task, and hence affect their task performance. Unfamiliarity with the task for both men and women was apparent. The physiological stress of the task was very heavy, as judged both by the subjects' heart rate response during the test, and the post-exercise blood lactate values (see Table B3.2). Both groups of subjects recorded near maximal heart rates at the conclusion of the task (females 181 and males 184 bpm). Their mean blood lactate values measured following this task were 63.9 mg% for females, 73.8 mg% for males; for comparison, corresponding maximal values achieved during all-out effort on the Wingate laboratory test were 58.3 and 73.5, respectively, for females and males.

Results showing the stepwise regression analysis comparing task performance to EXPRES variables are shown in Table B3.3. For the females, only age (R^2=0.43) was found to be a significant predictor variable whereas with the males only the step-test (R^2=0.16) predicting aerobic capacity was accepted in these analyses. Other variables in the EXPRES test battery were not found to be signficant predictors. Similarly, discriminant analysis performed to maximize Wilke's lambda (λ= 0.89), indicated that differentiation on a pass/fail basis on task performance through EXPRES variables was not significant (χ^2=9.01, p=.06). The classification function (Table B3.4) correctly classified 65% of cases.

TABLE B3.1. Low and High Crawl Performance by Subjects and Number of Subjects Achieving the Criteria.

SUBJECTS	TIME (s) LOW CRAWL (30m)	HIGH CRAWL (45m)	TOTAL	SUBJECTS ACHIEVING CRITERION.[1] NO.	%
FEMALES (n=21)					
Mean	78.5	70.0	148.6	0	0
S.D.(+/-)	26.6	50.4	68.5		
Range	48-140	46-290	94-420		
MALES (n=65)					
Mean	36.5	40.1	76.6	58	(88%)
S.D.(+/-)	7.1	8.5	14.3		
Range	24-60	29-86	57-139		

[1] Pass Criterion: 90 s to complete the tasks.

TABLE B3.2. Physiological Stress, as Determined by Heart Rate, and Blood Lactate for Low and High Crawl

SUBJECTS		HEART RATE COMPLETION OF TASK (bpm)	BLOOD LACTATE POST-TASK (mg%)[1]
FEMALES (n=21)			
	Mean	180.9	63.9
	S.D.(+/-)	13.0	8.5
	Range	156-198	47.4-81.7
MALES (N=65)			
	Mean	183.9	73.8
	S.D.(+/-)	13.2	9.3
	Range	156-204	57.6-99.6

[1] For comparison, mean maximal blood lactate values determined following the Wingate Laboratory Test were: females 58.3 ± 10.6 mg%; males 73.5 ± 14.1 mg%.

TABLE B3.3. Stepwise Multiple Regression Analysis: Prediction of Subjects' Performance (Total Time) on Low-High Crawl by EXPRES Variables.

Sex	Predictors	B	Beta	R	R^2	F	P
Females	Constant	-117.81					.141
	Age	10.30	0.65				.003
				0.652	0.425		.003
Males	Constant	122.52					<.001
	Step Vo_2	-0.92	-0.40				.002
				0.398	0.159	10.76	.002

TABLE B3.4. Discriminant Function Analysis of EXPRES Variables for Low-High Crawl.

Actual Task Performance			Predicted Performance Correctly Classified		Incorrectly Classified	
	n	%	n	%	n	%
Pass	53	71	34	64	19	36
			(True Positives)		(False Positives)	
Fail	27	29	18	67	9	33
			(True Negatives)		(False Negatives)	
Total	80	100	52	65	28	35

TABLE B3.5. Stepwise Multiple Analysis: Low-High Crawl Task Performance by Sex as a Function of EXPRES plus Laboratory Test Items

Females

Predictive Variables	B	SE B	beta	R	R^2	F	P
Leg Erg Power	-0.10	0.04	-0.45			7.39	.01
Constant	364.72	80.04				20.77	<.001
(equation)				0.45	0.20	7.39	.01

Males

Predictive Variables	B	SE B	beta	R	R^2	F	P
Armerg Power	-6.19		-0.34			8.35	.006
% Body Fat	0.97		0.29			6.21	.02
ILM Mass to 6'	-0.52		-0.27			5.53	.002
Constant	122.52						
(equation)				.052	0.27	6.81	.001

[1] Pass criteria: 90 seconds to complete crawl.

Further stepwise regression analysis entailed combining variables from both EXPRES and Laboratory test items. These derived equations are presented in Table B3.5 for men and women; for the females, leg ergometer power accounted for 20% of the variance, significant at the p=0.01; otherwise, no other variable appeared in this stepwise analysis. For the males, the significant predictor variables selected were arm ergometer power, % body fat and the maximum ILM lift; though significant (p<.001) those variables could account for only 27% (R^2 = 0.27) or the variance in performance data.

B3.5. Interpretation.

From observation of subjects doing the task, technique was judged very important in attainment of a good score. The subjects with the best scores used a total body undulation maneuver with the elbows and instep of the foot used for maximum propulsion. The most difficult phase of the crawl was the last half of the low crawl, at which point both muscle fatigue and breathlessness were experienced by all subjects; this seemed to be the phase where individuals changed their movement speed most dramatically. On the other hand, the low crawl phase had the greatest differences between the sexes with a mean difference of 42.0 s in comparison to the high crawl phase where the mean difference was reduced to 29.9 s. It was speculated that both technique and upper body strength could have been the main contributing factors of this difference, however, both the regression and discriminant analyses failed to substantiate this.

Regardless of the explanation of sex differences in performance time. it is clear that the task is a complex one and was novel to most of the subjects tested. If follows that performance of this task could be dependent on many variables. When EXPRES variables alone were used in the regression analysis, most of the variance in test results was not accounted for (women 43%, men 16%).

One aspect that needs to be addressed is the pass rate in women. As already mentioned, our subjective impression was that the female subjects preformed the low crawl in a lower body position, one consequence of which would be slower movement rate in the crawl; however, one would not expect this difference to account for a doubling of their low crawl time in comparison with the men. Our understanding is that the pass criterion was arbitrarily selected. On the basis of the above observation, and in light of the high fail rate in women versus the high pass rate in men, it would appear there is a clear need to determine pass standards on a rationalized basis, with due regard for gender differences, plus safety under fire.

One further point is noted: that the task was physically very demanding. From the duration of the task, the heart rates achieved and the post-exercise exercise blood lactate values, one would conclude that it was a high power, anaerobic type activity. Moreover, the task would appear to require upper body strength, though technique without doubt is an important variable upon which good performance is dependent.

B3.6. Conclusions.

From the above data, it is clear that the conclusions which can be drawn are limited, particularly with respect to task performance by women. Some of the reasons leading to this limitation are discussed above and need no further reiteration. Within these reservations, the following conclusions are suggested by the data:

1. EXPRES variables above are of limited value as predictors of low-high crawl performance.
2. Addition of laboratory test variables marginally improved performance prediction.
3. That high upper body strength variables apparently are of particular importance, as indicated in the regression anaysis; however, discriminant function analysis did not support this conclusion.
4. That the task was physically demanding in the physiological sense, effecting both high terminal heart rates and blood lactate measurements in all subjects. Surprisingly, anaerobic fitness variables were not shown as reliable predictors of task performance.

SECTION B4.

ENTRENCHMENT DIG TASK

SECTION B4.

ENTRENCHMENT DIG TASK

B4.1. Statement of Problem

The task was a simulation of a one-person foxhole dig under combat conditions. In the same field area on the CFB Kingston Base, each Forces Personnel dug an individual foxhole.

Performance Criteria - Dig emplacement (45 min): Each subject to dig a one-person foxhole to a depth of 18 inches in soil of medium firmness with no rocks or large roots using the entrenching tool. The foxhole is approximately 6 ft. long and 2 ft wide.

B4.2. Summary of Literature

Summaries of previous studies of military personnel (Passmore & Durnin, 1955) and coal miners (Morrissey et al., 1983) indicate that emplacement digging requires significant energy expenditure. From military studies, Passmore & Durnin (1955) examined work output which ranged from 276 kcal/hr to 528 kcal/hr. The most recent estimation of coal-miners' energy expenditure was 408 kcal/hr (Morrissey et al., 1983). This value was in excellent agreement with previous research both on coal-miners miners (Morrissey et al., 1983) and military personnel (Passmore and Durnin, 1955). Chakraborty et al. (1974) determined that oxygen consumption was sustained at 29.1 ml/kg/min, the equivalent of up to 69% of their subjects' maximal aerobic capacity, while heart rates have been sustained well over 130 beats/minute during prolonged digging. On the other hand, only a modest rise in blood lactate has been recorded, 34.8 mg% post-dig (Chakraborty et al., 1974). In summary, it appears that workers naturally select an optimal energy expenditure of approximately 400 kcal/hr.. This work rate permits a high peak efficiency while digging over a prolonged period of time without experiencing undue fatigue; this corresponds to an oxygen consumption of approximately 1.5 litres/minute.

In the preliminary studies conducted by the present investigators (in May, on Forces Personnel, and June, using civilian subjects) similar data were recorded (see Appendix D). However, relative to the designated performance criteria, two difficulties were encountered. First, short-handled, square-blade spades (ones commonly sold in hardware stores) were employed as the entrenching tool (army issues were unavailable). Second, during the testing in July at CFB Kingston (in the same field where all preliminary work had been conducted), the lack of rain for several weeks made the ground EXTREMELY difficult to dig, whereas the criteria specified: "... soil of medium firmness...". Consequently, the results presented below for the entrenchment dig are tempered by these factors and discussed in light of these two problems encountered.

B4.3. Methodology

The purpose of this task was to dig an entrenchment as quickly as possible measuring 2' x 6' x 18" in depth. This task was designed to replicate battlefield conditions.

Details of the method and protocol employed are explained in Apprendix C. In brief, the dig site for teach subject was outlined using white lime. On command, the subject worked against time to complete the task as quickly as possible. Most usually, the subject dug on the inside border of the white line and the soil was piled lateral to the ditch approximately 2' away from either side. Rest intervals were self-determined at any point during the task, and the only specific advice given regarding technique was that excessive forward bending should be avoided in order to reduce the stress on the lower back. Subjects were permitted fluids (water, orange juice) ad libidum. Using the depth marker, the experimenter determined when the task had been completed.

The time to complete the dig was recorded, as well as heart rates throughout and depth of the dig at varied time intervals. Specifically the variables recorded were:

1) at 10 minutes a depth rating;
2) at 15 minutes a heart rate;
3) at 25 minutes a heart rate;
4) at 45 minutes a depth rating;
5) the final depth rating and heart rate; with the total time of the dig recorded.

To record heart rate, the experimenter manually took a 10-second second pulse count on the subject. As well throughout the dig, periodically the wooden measuring frame was used to guide the subject (as to length and width of the foxhole) and to judge when the dig was correctly completed. Upon completion of the task the subject was asked questions regarding both localized and general feelings of fatigue.

B4.4. Results

An important point to note that had profound effects on task performance were the soil conditions at the time of testing. Soil analysis at the CFB Kingston test site indicated a clay content of 98%, a value which would be consistent with the whole region. However, between the time of the pilot studies and testing date, the moisture content (not measured) was reduced and, as a consequence, the soil became hard-packed making digging extremely difficult; a change in dig location did not alleviate the problem. Clearly, this had implications on the time limit criterion set for performance of the task; however, since the dig conditions in general were similar for all subjects, the performance time would presumably be affected on a relative basis.

Table B4.1, summarizing the results of the entrenchment dig for men and women, shows their respective "completion" times, 51.0 ± 17.4 and 92.8 ± 21.8 (respectively); of the 21 females, 13 completed the dig though none did so within the performance time criterion of 45 minutes.

For the males, 63 of 66 subjects completed the dig but only 29 (44%) met the time criterion. Of interest is the contrast between both sets of these data and preliminary tests in which all males and 33% of the females achieved the time criterion (see Appendix D): of the forces personnel, one female recorded the fastest dig time; of the civilian females in separate pilot work, all completed the task within 45 minutes. Furthermore, it must be noted that "completion" time for all who had not completed the dig by 60 minutes are extrapolated times, pro-rated on the basis of their degree of completion after one hour.

On this account, limited interpretation can be made of these results beyond the obvious fact that dig times were markedly prolonged reflecting primarily the soil conditions.

Evidence that the task was physically demanding is indicated by heart rate responses (Table B4.2) which approximated 160 bpm for each gender, with some subjects reaching final values as high as 186 bpm. In part, these high heart rates can be attributed to the high ambient temperature of the test day (i.e., 30° C) which further heightened the physiological stress of the task.

Understandably, in light of the problems (cited above) encountered in performing the entrenchment dig, and the inherent errors of the extrapolations to estimate dig time, statistical analysis of these data cannot be carried out with a high measure of confidence. Thus, the results shown in Tables B4.3, B4.4 and B4.5 are included in the interest of completeness; no firm conclusions can be drawn from these analyses. Consistent with observations noted for other tasks, EXPRES variables alone - Combined grip and Push-ups - were high predictors of performance for females (R^2 = 0.82), but not for males. Combining EXPRES with laboratory test items, four variables were selected for women (flexed arm hang, combined grip strength, ILM at T4 and combined endurance grip) but yielded poorer predictions than for EXPRES alone (R^2 = 0.63). Discriminant analysis indicated EXPRES variables could correctly predict pass/fail in 59% of the cases.

B4.5. Interpretations

From the discussion included in the presentation of results (above), it is clear that these results should not be accepted as a valid reflection of the possible relation of physical fitness to entrenchment digging. The reasons for this have already been addressed; specifically: the soil conditions, along with the extrapolations to estimated finishing time because of the inordinately long dig time required.

Soil conditions contrasted markedly with those of our preliminary studies, despite all tests being conducted at the same site (though naturally not in the same holes). Moisture content of the heavy clay soil, though not quantified, was clearly markedly lowered between late May and early July, the time of the field test. This was associated with extreme soil compaction such that the lighter weight subjects had extreme difficulties in penetrating the soil Use of a hand pick would have

TABLE B4.1. Entrenchment Dig: Times[1] and Number of Subjects Achieving the Criteria.

SUBJECTS	COMPLETION TIME (min.)	SUBJECTS ACHIEVING CRITERION[2]	
		NO.	%
FEMALES (n=13)			
Mean	92.8	0	0
S.D.(+/-)	2.8		
Range	(62-120)		
MALES (n=63)			
Mean	51.0	29	43.9
S.D.(+/-)	17.4		
Range	(26-102)		

[1] All times over 60 minutes are estimates of completion time only, and not actual completion time. In some cases, this estimation was not possible - thus the decreased number of women subjects for this table.

[2] Pass Criterion: 45 minutes to complete entrenchment dig.

TABLE B4.2. Physiological Stress, as Determined by Heart Rate, throughout Subjects' Entrenchment Dig.

SUBJECTS	HEART RATE RESPONSE (BEATS/MINUTE)			
	PRE-DIG	FIRST HALF	SECOND HALF	FINAL
FEMALES (n=19)				
Mean	97.2	157.0	156.0	N/A
S.D.(+/-)	7.3	14.1	14.7	N/A
Range	(84-114)	(138-180)	(132-186)	N/A
MALES (N=66)				
Mean	86.7	159.6	157.2	157.9
S.D.(+/-)	13.5	18.9	32.7	16.0
Range	(66-126)	(120-198)	(120-192)	(138-186)

TABLE B4.3. Multiple Regression Analysis: Prediction of Subjects' Dig Time from EXPRES Variables.

Sex	Predictors	B	Beta	R	R^2	F	P
Females	Constant	216.31	0				<.001
	Combgrip	-1.15	-0.65				.002
	Pushup	-1.11	-0.54				.005
				0.903	0.815	19.80	.001
Males	Constant	68.76	0				<.001
	Situp	-0.41	-0.24				.069
				0.243	0.059	3.44	.069

TABLE B4.4. Discriminant Function Analysis of EXPRES Variables for Entrenchment Dig.

	Actual Task Performance		Predicted Performance			
			Correctly Classified		Incorrectly Classified	
	n	%	n	%	n	%
Pass	24	71	11	46	13	54
			(True Positives)		(False Positives)	
Fail	56	29	37	66	19	34
			(True Negatives)		(False Negatives)	
Total	80	100	48	59	32	41

TABLE B4.5. Stepwise Multiple Analysis: Entrenchment Dig Task Performance for Women[1] as a Function of Raw Scores of EXPRES and Laboratory Test Items.

Females

Predictive Variables	B	SE B	beta	R	R^2	F	p
Flexed Arm Hang	-0.46	.11	-0.54			18.30	<.001
Combined Max Grip Raw	-0.32	.16	-0.25			3.83	.06
T4[2]	-45.75	14.61	-0.39			9.81	.004
Combined End Grip	-0.09	.03	-.034			7.27	.012
Constant	164.00	13.59				145.66	<.001
(equation)				0.79	0.63	10.94	<.001

[1] No predictor variables could be determined for males.

[2] T4 - ILM test time at which force was minimum (i.e., usually at the point of wrist change over).

improved the dig performance but this would have changed the task from that defined by DPERA.

Despite the short-comings of the results, and the resultant limits on interpretations that can be made, the efforts of the subjects should not go un-noticed. The task was exceedingly difficult, as well as frustrating for the subjects because of their rate of progress. Notwithstanding this, there was a high perseverance level which paralleled the sustained high physiological stress noted throughout the dig.

B4.6. Conclusions Before any conclusions can be drawn, the test would need to be completed under tightly controlled experimental conditions.

SECTION B5.

SEA STRETCHER CARRY TASK

SECTION B5.

SEA STRETCHER CARRY TASK

B5.1. Statement of Problem.

The task was a simulation of a casualty evacuation during a fire on-board ship. The subjects were required to carry an 80 kg Stoker stretcher (simulating a wounded person) up and down one deck. This phase of the study was carried out at CFB Halifax.

Performance Criteria. While in fire-fighting gear a two-person team moved the stretcher (with 80 kg) a horizontal distance of 12.5 m, followed by moving the stretcher up one deck, then down again and back to the starting point. The time allotted for completion of this task was 10 minutes.

B5.2. Summary of Literature.

A limited number of studies (Astrand & Rohdal, 1977; Bobbert, 1960; Datta & Ramanathan, 1970; Gordon et. al., 1983; Orsini & Passmore, 1951; Pimental & Pandolf, 1979; Ramanathan & Datta, 1968) have examined the physical stress and energy requirements of load-carrying working against gravity (i.e., up a grade, stairs, etc.). In Section B2.2 we have summarized the available literature dealing with the land stretcher carry task (see overland load-carrying review in Section B2.2). When this literature is contrasted with research on load-carrying having a vertical component, three obvious distinctions are that vertical load-carrying:

i) is more fatiguing than overland load-carrying, and is proportional to the load being raised;

ii) is less likely to achieve steady-state, compared to overland submaximal carrying;

iii) involves a larger anaerobic energy component, as judged by post-exercise blood lactate values.

Evidence supporting the high energy cost of vertical work is convincing. Orsini & Passmore (1951), studying four different support and movement methods using a 37 kg load, concluded that compared to moving the same load overland, walking downstairs almost doubled the energy requirments of the subjects'; walking upstairs more than tripled their energy expenditure. Similarly, Astrand & Rodahl (1977) determined that continuous stair climbing while carrying 13.6 kg required 4.2 litres/min. oxygen consumption, a near maximal value for their subjects; also, this resulted in near-maximal lactate values for both female and male subjects.

Other aspects of load-bearing have also been examined. Evans et al. (1983) compared the maximal time which their subjects could hold a 40 kg load (a compact box container) standing, versus carrying it on the level; under the latter experimental conditions the time to exhaustion was reduced by one-third, and near maximal heart rate response was observed. Lind & McNicol (1966, 1967, 1968) in a series of studies reported on the effects of load-carrying (20 kg) and recovery from such work. These investigators concluded that load distribution was important (i.e., one-hand carrying 20 kg versus two-handed, 10 kg per hand); even-distribution improved subjects' performance significantly and local fatigue was reduced. On the other hand, following exhaustion from load carrying a lengthy time period was required for complete recovery by subjects of their load-carry capacity; this despite heart rate, blood pressure and local blood flow all having returned to pre-exercise conditions within 15 minutes. As well, if load-carrying was repeated before full recovery, subjects time to exhaustion was reduced accordingly (Lind & McNicol, 1967).

In preliminary work carried out by the present investigators, similar results were found and investigator observations confirmed the same trends subjectively (see Appendix D). Specifically, to carry the weighted Stoker stretcher up one flight of simulated shipboard stairs elicited near maximal heart rates and the sensation of moderate to extreme fatigue. On these basis the task was judged physically demanding, requiring high measures of strength as well as other fitness components. However, the application of this task as a field test posed a unique problem which could not be resolved in advance of the target testing date. Since the task required two persons, performance could in theory be limited by one and not necessarily by both of the subjects. This problem was resolved in the land stretcher carry by use of a "super subject", but this solution was not appropriate for sea stretcher carry as this task was highly dependant on the "team" approach, one subject possibly off-setting to a degree weakness of the partner. This testing problem was only partially resolved (see Methodology below).

B5.3. Methodology.

In preliminary testing in Kingston (June, 1985), upper body strength was judged to be an important factor in success or failure of the sea strether carry (see Appendix C). On this basis, and to attempt resolution of the above problem of "team" performance, two steps were taken. Firstly, subjects were grouped according to their maximum grip scores in order to minimize the effect of one subject on the team's performance; and secondly, for the men only, two trials were completed with team members eversing positions on each carry in order to determine if performance was affected by the carrying position of a subject, as well as by learning. Since the performance time from preliminary on site analysis was not significantly affected by position nor repetition, the females were required to perform only a single trial. Statistically, each pair of subjects was treated as a single entity in performing the following task. The protocol, outlined in detail in Appendix C, entailed a two person team clad in fire-fighting gear carring an 80 kg stretcher a total horizontal distance of 25 m, ascending and descending one set of between deck stairs (which exactly simulated that of a ship on quiet seas). The variables measured were:

1) time to stairs,
2) time of ascent.

3) heart rate at top,
4) time of descent,
5) total time,
6) final heart rate, and
7) final blood lactate level at the completion of the task.

This test was intended to simulate evacuation of military personnel; therefore, before commencing the task it was explained to the subjects that the task should be completed as quickly as possible, yet with due care for injury for both the carriers and the "wounded" evacuee. Toward this end, during the stair ascent and descent, a safety rope was attached to the stretcher at all times in case of accident. In the protocol, subjects were matched according to similar maximal handgrip scores. On the command "START" the team carried the stretcher 12.5 m to the stairs and ascended so that both partners reached the top deck. At the top, 15 s heart rates were taken by investigators, except in those few subjects on whom heart rates were being telemetrically determined (and their times adjusted appropriately). At the subjects' discretion, the team resumed the task by descending the stairs and returning the stretcher to the starting position. Following determination of final heart rates, both subjects proceeded to the laboratory test station where a 2-3 ml, venous blood sample was withdrawn; usually this was done within 4-5 minutes post-test.

For the men, after full recovery from the first test, a second trial was performed using the same protocol (as above) but with the subjects' position reversed and without blood sampling.

B5.4. Results.

For reasons sited above, and because of the difference in shape of each end of the Stoker stretcher and the consequent possible relation to one's body posture while lifting, the men were asked to perform the task twice, reversing their carrying positions between trials. Based on preliminary analysis using a paired t-test, no significant difference between tests was found and, accordingly, the females were required to complete the evacuation task only once. Also, for the men the average times for the two carries was used in data analysis. Total mean times by group for men and women, and the summary of pass/fail performance are contained in Table B5.1a. Mean time for the women (N=4 pairs, 8 indivduals) was 484.8 s.; three of the teams performed the task within the time criterion (10 minutes), with two teams failing to complete the task, and one team failing the time criteria. The mean values for each of Trial 1 and Trial 2 for men are also shown. Both trials were completed within ten minutes, the time for Trial 2 being only marginally less (i.e., 8 s.) than for Trial 1. All men completed the task easily within the time criterion.

To provide insight into the components of the task and the relative times required, the split times are presented in Table B5.1b. The portion of time required by females to complete the stair ascent approximated 55% of the total for the three times cited, approximately twice that for descent. In contrast, the ascent for men required about 40% of these

TABLE B5.1A. Sea Stretcher Carry: In Subject Pairs, the Final Times for Completion of the Task and Number of Subjects Achieving the Criteria.

SUBJECT POPULATIONS	TOTAL TIME (seconds) Trial 1	Trial 2	NUMBER AND % OF SUBJECTS ACHIEVING CRITERIA NO.	%
FEMALES[1] (n=12)				
Mean	484.8	N/A[2]	3	(50%)
S.D.(+/-)	108.7			
Range	422.0-647.0			
MALES (n=36				
Mean	127.4	119.4	61	(100%)
S.D.(+/-)	42.2	46.4		
Range	69.0-233.0	73.0-221.0		

[1] This includes the 2 pair who were judged to have not completed carry (helped by safety ropes).
[2] Each pair of female subjects performed only one trial.

TABLE B5.1b. Sea Stretcher Carry: In Subject Pairs, Intermediate Time to Completion of Evacuation Task.

	TIME TO STAIRS Trial 1	Trial 2	TIME TO ASCEND Trial 1	Trial 2	TIME TO DESCEND Trial 1	Trial 2
FEMALES						
Mean	39.7	N/A	317.0	N/A	126.8	N/A
S.D.	8.9		132.0		66.0	
Range	32-59		150-538		55-234	
MALES						
Mean	13.4	12.1	31.9	31.3	36.1	32.8
S.D.	4.9	3.9	14.9	17.8	17.3	17.1
Range	7-27	8-19	16-60	11-66	15-88	9-74

total times, and a slightly higher fraction of time was required for descent. These data suggest the greatest difficulty with the task for women was in the lifting associated with the stair climb and in particular, passage through the deck hatch at the top of the flight of stairs (leading on to the top deck).

The intensity of the task is reflected in the measure of heart rate shown in Table B5.2. For both the men and women, the high mid-point and terminal heart rates indicated high intensity exercise which, not surprisingly, was all the more so for the female subjects. The blood lactate values are compatible with the view en that such exercise entailed a significant "anaerobic" component; however the total time required by the women also indicates high aerobic contribution as well.

Table B5.3 presents the simple multiple regression correlation analysis for men, comparing EXPRES variables only in relation to task performance; the low number of females precluded similar analysis of their data in both these correlational as well as in the stepwise regression analyses. A significant relationship ($p=0.047$) was observed when both combined grip strength and situps (from EXPRES) were included in the equation. With a correlation of 0.68, these variables however accounted for only 46% of the variance ($R^2=-0.457$). Discriminant analysis (see Table B5.4) indicated that EXPRES was able to correctly classify 67% ($p=0.35$).

Finally, Table B5.5 presents the equation derived from the stepwise regression analysis including variables from both EXPRES and laboratory test variables, including ILM. Selected variables included leg and arm ergometer power, along with flexed arm hang, all from the laboratory items. Though significant as a prediction equation ($p=0.001$) the correlation and variance values were low (0.50 and 0.25 respectively).

B5.5. Interpretation.

The sea stretcher carry task was performed, during rain, on a simulated ship setting; this implies that doorways and stairs were wet and narrow, and many of the turns were tight. Thus the task was such that at times the subjects had to lift in mechanically disadvantageous positions. Moreover this disadvantage often was borne more by one carrier than the other since both were just learning the task. For this reason, it will be appreciated that often the time required for a particular phase of the carry may well have been determined by one of the subjects. This was one of the reasons for pairing subjects according to some measure of strength, especially upper body which was most required in the disadvantaged positions. In practice, of course, this pairing would not prevail, in which case the stronger of the two carriers might be expected to contribute disproportionately at these key portions of the task. Doubtless, it was this pairing which accounted in large part for the wide range in total time for the men (69-233 s.) as well as the women (422-647 s.); had the pairing been selected randomly, this range would be expected to be much narrower. The point to be taken from this is that performance of this task, being a two-person event, was strongly dependent on the combined skills and muscular strengths of the teams;

TABLE B5.2. Physiological Stress of Sea Stretcher Carry Task as Determined by Heart Rate and Blood Lactate.

SUBJECTS		HEART RATE, HALFWAY (beats/min)		FINAL HEART RATE (beats/min)		BLOOD LACTATE
		Trial 1	Trial 2	Trial 1	Trial 2	Post Exercise (mg%)
FEMALES (n=12)[1]						
	Mean	184.0	-	176.5	-	64.6
	S.D.(+/-)	11.3	-	13.2	-	20.8
	Range	(168-204)		(150-192)		(61-86)
MALES (N=36)						
	Mean	155.2	161.8	159.6	165.1	59.7
	S.D.(+/-)	30.0	29.8	31.6	32.0	15.0
	Range	(132-192)	(138-186)	(114-198)	(132-210)	(39-89)

[1] Two pairs failed to complete the task.

TABLE B5.3. Multiple Regression Analysis: Prediction of Subjects Performance on Sea Stretcher Carry Task from EXPRES Variables.

Sex	Predictors	B	Beta	R	R^2	F	P
Females[1]							
Males	Constant	50.56	0				<.001
	Height	-0.12	-0.45				.005
	Weight	-0.13	-0.27				.002
	Situp	-0.11	-0.27				.040
				0.446	0.199	4.48	.007

[1] insufficient data

TABLE B5.4. Discriminant Function Analysis of EXPRES Variables for Sea Stretcher Carry.

	Actual Task Performance		Predicted Performance			
			Correctly Classified		Incorrectly Classified	
	n	%	n	%	n	%
Pass	35	90	22	63	13	37
			(True Positives)		(False Positives)	
Fail	4	10	4	100	0	100
			(True Negatives)		(False Negatives)	
Total	39	100	26	67	13	33

Table B5.5. Stepwise Multiple Regression Analysis: Sea Stretcher Carry Performance by Sex as a Function of EXPRES Plus Laboratory Test Items.

Females [1]

Males

Predictive Variables	B	SE B	beta	R	R^2	F	p
Leg Erg power	-0.01	.01	-0.20			3.16	.08
Arm Erg Power	-0.04	.01	-0.32			8.07	.01
Flexed Arm Hang	-0.47	0.17	-0.25			7.81	.01
Constant	241.90	20.38				139.95	<.001
(equation)				0.50	0.25	11.27	<.001

[1] insufficient data

on the other hand, the importance of muscle strength variables were not clearly evidenced in the stepwise regression analysis, although two variables closely related to pure muscle strength (arm ergometer power and flexed arm hang) were selected (see Table B5.5).

That the task was physically demanding is documented by both heart rate and post-exercise blood lactate levels, combining high power output for short intervals (i.e., anaerobic in nature), and for the women as well, a substantial endurance component. EXPRES variables, generally accepted as indicators of general fitness, did not prove to be significant predictors in the discriminant analysis ($p=0.35$) even though subjects were correctly classified 65% of the time; and no EXPRES variables were selected in the stepwise analysis.

Of the task performance by females, it must be pointed out that there were two ergogenic aids that may have had an effect on their performance (3 of 4 teams completing the task; three within the time criterion). Vocal support by fellow subjects, as well as testers was obvious; on a subjective basis as well, concern and resultant assistance on the safety rope was provided some women in specific instances. Notwithstanding these factors, it is clear that most of the present population, despite lack of specific previous training, in general were capable of performing this very difficult task.

B5.6. Conclusions.

The sea stretcher carry task was unique in that it required high peak force and power, and often in postures that rendered mechanical advantage of movement and lifting low. These results suggest the following.

1. The task, on the basis of physiological stress, would be classed as heavy for men and intense for women, and proved very demanding physically. Aside from the physical lifting component, the heavy fire-fighting apparel, oversized footwear and close working quarters increased the intensity of the task as well as the risk of injury.

2. Task performance on repeated carries was not significantly altered by the carrying position of subjects; however, in the present application, subjects were matched using one strength variable and this may have biased the results.

3. Prediction of performance using EXPRES variables alone, or in combination with laboratory items, including ILM, proved unreliable.

4. The few numbers of female subjects precluded statistical analysis. This data indicates that most of the present population, who ranked about the 80th percentile amongst their peers, were capable of performing the task, though completion time was about five-fold greater than for the men. However the tasks was completed within the designated time allotment.

SECTION B6.

FIRE-FIGHTING TASK

SECTION B6.

FIRE-FIGHTING TASK

B6.1. Statement of Problem.

The subject extinguished five fires wearing fire-fighting gear and a Chemox Self-Contained Breathing Apparatus (SCBA). Betweeen fires the subject was required to ascend and descend one deck while controlling 15 m of charged hose.

Performance Criteria: in fire-fighting gear and using breathing apparatus and in varying temperatures, control 50 ft. (15 m) of charged hose for 30 minutes climbing and descending one deck. (CFB Halifax)

B6.2. Summary of Literature

Numerous studies (Barnard and Duncan,1975, Davis et al., 1982b, Griggs, 1977, Kilbom, 1980, Lemon and Hermiston, 1977, Manning and Griggs, 1983) have investigated the physiological demands of a variety of fire-fighting skills in adult males. There has also been extensive work on the effect that the additional stressor of a breathing apparatus has on fire fighters (Davis et al., 1982a, Davis et al., 1982b, Griggs, 1977, Kilbom, 1980, Louhevaara et al., 1985, Manning and Griggs, 1983). Although the results are varied, the literature is in general agreement that fire-fighting is physically demanding and requires substantial energy output, independent of the specific task being performed. Furthermore, the protective clothing and breathing apparatus worn add to both the physiological demand and the mechanical difficulty of such tasks.

The heart rate of fightfighters quickly increases during the approach to the fire (Barnard and Duncan,1975). While actually performing fire fighting tasks, heart rates are raised to 90 - 100% of maximum (Davis et al., 1982b, Griggs, 1977, Manning and Griggs, 1983). Average oxygen consumption has been recorded at 1.9 l/min. (Kilbom, 1980), and as high as 97% of maximal O capacity (Davis et al., 1982a), but more realistically falls between 60 - 80% MVO (Lemon and Hermiston, 1977). Energy expenditure was calculated to be greater than 660 kcal/hr (Lemon and Hermiston, 1977) on four fire-fighting tasks. The same investigators estimated that the anaerobic contribution during these tasks was between 41% and 75% of the total energy expenditure. The effect of a SCBA over a range of workloads on a treadmill was to increase heart rate and oxygen consumption in a linear fashion (Louhevaara et al., 1985). The SCBA's effect during fire fighting tasks of moderate workload was reported to be a decrease in work efficiency (Davis et al., 1982a), and an increase in the energy cost of the task (Davis et al., 1982b). It has been stated that the fire fighter adapts to the cardiovascular burden of an SCBA by adjusting his workload to maintain an 85-100% exertion level (Manning and Griggs, 1983).

In preliminary work conducted by the present investigators in Halifax in May 1985 at the Forces Training School, the results obtained were in general agreement with these literature findings, with one important addition: while the subjects (both females and males) heart rates were elevated to 160-175 beats/min (see Appendix D), even the largest males could not continuously hose for 7 minutes using the low-velocity nozzle. This did not even closely approximate teh DPERA guidelines of 30 minutes of continuous hosing while also going up and down stairs. Since the physiological stress was judged to be moderately high, but not maximal, it was concluded that local muscular fatigue was the limiting factor in task performance.

B6.3. Methodology

Details of the method are contained in the Manual of Schedules and Protocols (Appendix C). Testing was performed on a simulated shipboard. Over a 30 minute period, starting at ground level subjects were required to ascend by stairway one deck, extinguish a large pan fire, return to ground level and repeat this task 5 times in quick succession while clad in fire-fighting gear and using the SCBA. The variables studied were:

1) time to stair ascent (1-5);
2) heart rates after stair ascent (1-5);
3) time from fire out to bottom of stairs (1-5);
4) time to put out fires (1-5);
5) total time; and
6) final heart rate.

The design of this task required each subject to use the low velocity hoses. In order to accomplish this goal, personnel required training in the following:

a) clothing requirements for task
b) instruction on use and safety with breathing apparatus
c) training in techniques of fighting large and small fires (primarily oil)
d) holding and use of high and low velocity nozzles while going up and down a staircase
e) instruction to personnel who are in charge of manning the hoses

The subjects were started 10 m from the foot of the stairs oufitted in the fire-fighting gear and breathing through the Chemox SCBA. Two assistants, also wearing the fire fighting gear, helped to carry the trailing hose. On the command "START", the subject moved quickly to the stairs and ascended toting the hose charged at 200 lb, a low velocity adaptor attached and in the "OFF" position (handle in the forward position). Upon reaching the pan fire on the upper deck, the subject turned the nozzle on (mid-position) and proceeded to extinguish the fire using prescribed technique (i.e., angle of nozzle, frequency of sweeping, hand grip, etc.). After the investigator determined that the fire was out, the nozzle was turned to "off" and, the subject descended the stairs backwards to the bottom. Subjects repeated the task as outlined until 5 fires were extinguished.

Heart rate was monitored manually, or by telemetry, at regular intervals throughout the task. The test was stopped if: I) inadequate respiration occurred from the Chemox SCBA; 2) muscle fatigue occurred prohibiting safe, useful techniques; 3) after 30 min. of elapsed time.

B6.4. Results

In total, 12 females and 31 males attempted the fire-fighting task, all of whom extinguished the five fires well within the 30 min. time criterion (see Table B6.1). (Females Mean = 10.4 ± 2.5; Males Mean = 5.8 ± 1.9 min.). Table B6.2 lists the heart rate responses before, at the completion of each of the five trials, and at the end of the task. For the females, mean heart rates during the trials varied from 161 - 173 bpm from Trial 1 through Trial 5. Heart rates for men were only marginally lower, despite their faster performance rate: mean values rose progressively from 154 bpm in Trial 1 to 170 bpm in Trial 5. Complete heart rate data was not recorded for all male subjects (see footnote below Table B6.2).

B6.5. Interpretation

Because all subjects completed that task well within the performance time criterion, there was little basis for discrimination between subjects on their task performance, and further statistical analysis was unwarranted as well.

Several observations were worthy of note, however. While the task was performed easily by all subjects this may be attributable to both the very careful monitoring by well experience professional staff, and to the assistance provided in the hose carrying, though not the nozzle handling. These steps were taken as safety measures, not only to protect against injury but also to guard against the possibility of severe respiratory distress associated with the Chemox apparatus. The SCBA was indeed a source of substantial discomfort as well as subject stress. This was attributed to the "lung" arrangement of the system which subjects would often inadvertently collapse by external pressure during the task. This necessitated assistance to subjects between many of the trials; such time as was required for this purpose was not included in the test time. The problem was doubteless exacerbated by the fact many of the subjects claimed they had little or no direct experience with the Chemox system. Clearly, with experienced subjects fewer problems would be expected and, thus, a reduced stress during the test expected.

TABLE B6.1. Fire-Fighting Task Performance: Total Time Required to Extinguish Five Pan Fires, and Number of Subjects Passing the Criterion.

SUBJECTS	TOTAL TIME (min.)	SUBJECTS ACHIEVING CRITERION[1] NO.	%
Females (n=12)			
Mean	10.4	12	(100%)
S.D.(+/-)	2.5		
Range	6.0-14.8		
Males (n=34)			
Mean	5.8	31	(100%)
S.D.(+/-)	1.9		
Range	3.2-9.2		

[1] Pass Criterion: 30 minutes to complete 5 trials.

TABLE B6.2. Heart Rate Response During Fire Fighting Task.

SUBJECTS	HEART RATE RESPONSE (BEATS/MINUTE)					
	TRAIL NUMBER					
	1	2	3	4	5	Finish
Females (n=12)						
Mean	161	168	169	170	173	170
S.D.(+/-)	10.9	9.9	11.7	11.6	10.2	14.3
Range	138-175	153-184	150-185	149-190	159-193	147-191
Males[1] (n=23)						
Mean	154	162	163	164	170	163
S.D.(+/-)	16.2	15.0	15.7	18.5	16.5	19.5
Range	128-175	120-190	128-188	113-194	110-198	96-187

[1] Note: heart rate data for every trial was not recorded on male subjects (n=23-27) for trials 1 to 5.

SECTION B7

INCREMENTAL LIFTING MACHINE ANALYSIS

SECTION B7

INCREMENTAL LIFTING MACHINE ANALYSIS

B7.1. Introduction.

The Incremental Lifting Machine was provided through DCIEM to the Queen's University Laboratories on a previous contract (Stevenson, et al., 1984). The device has been proposed for use in screening recruits prior to military service. In this study, it was added to the battery of tests used to predict task performance.

The device operates as shown in Figure B7.1. Using a horizontal handle bar, the subject lifts a mass which is guided along a vertical rod. The subject must, in one smooth motion lift the mass to a height of six feet without stopping. If successful, the task is repeated using ten pounds (4.54 kg) more mass for males or five pounds (2.72 kg) more mass for females. The mass of the last successful lift is recorded as the ILM score.

In a previous contract, we developed a technique by which kinetic data could be continuously obtained from each lift. To do this, a transducer was provided which could be attached to the moving mass. This provided displacement and speed as a function of time for the moving mass. As shown in Figure B7.2, these data could be further processed when acquired using a microcomputer. Filtering and differentiating the velocity data provides acceleration. Recognizing the relationship between force, weight, mass and acceleration as shown in Figure B7.2 enables the assumed applied force by the test subject to be calculated. Finally, it is also possible to calculate power by taking the product of force and velocity.

The ability to obtain information regarding the temporal relationships for displacement, velocity, acceleration, force and power greatly increases the ability to analyze a lift on the ILM.

B7.2. Typical Kinetic Profile.

Typical results for kinetic variables measured as functions of time are shown in Figure B7.3. All plots are aligned so they share a common ordinate which has two scales. The first scale is time (in seconds), while the second is normalized to represent phases within the lift as "percent of lift cycle".

Displacement versus time is shown in Figure B7.3a. Here, the event called zero was identified as the time at which the lift had been completed at six feet. Velocity versus time (Figure B7.3b) showed two characteristic peaks. The first (Event 1), was the peak speed, usually observed at 40% to 50% of the lift. Event 2 was the speed obtained as the lift was completed. Of note is the fact that this speed dropped to zero in an unsuccessful lift.

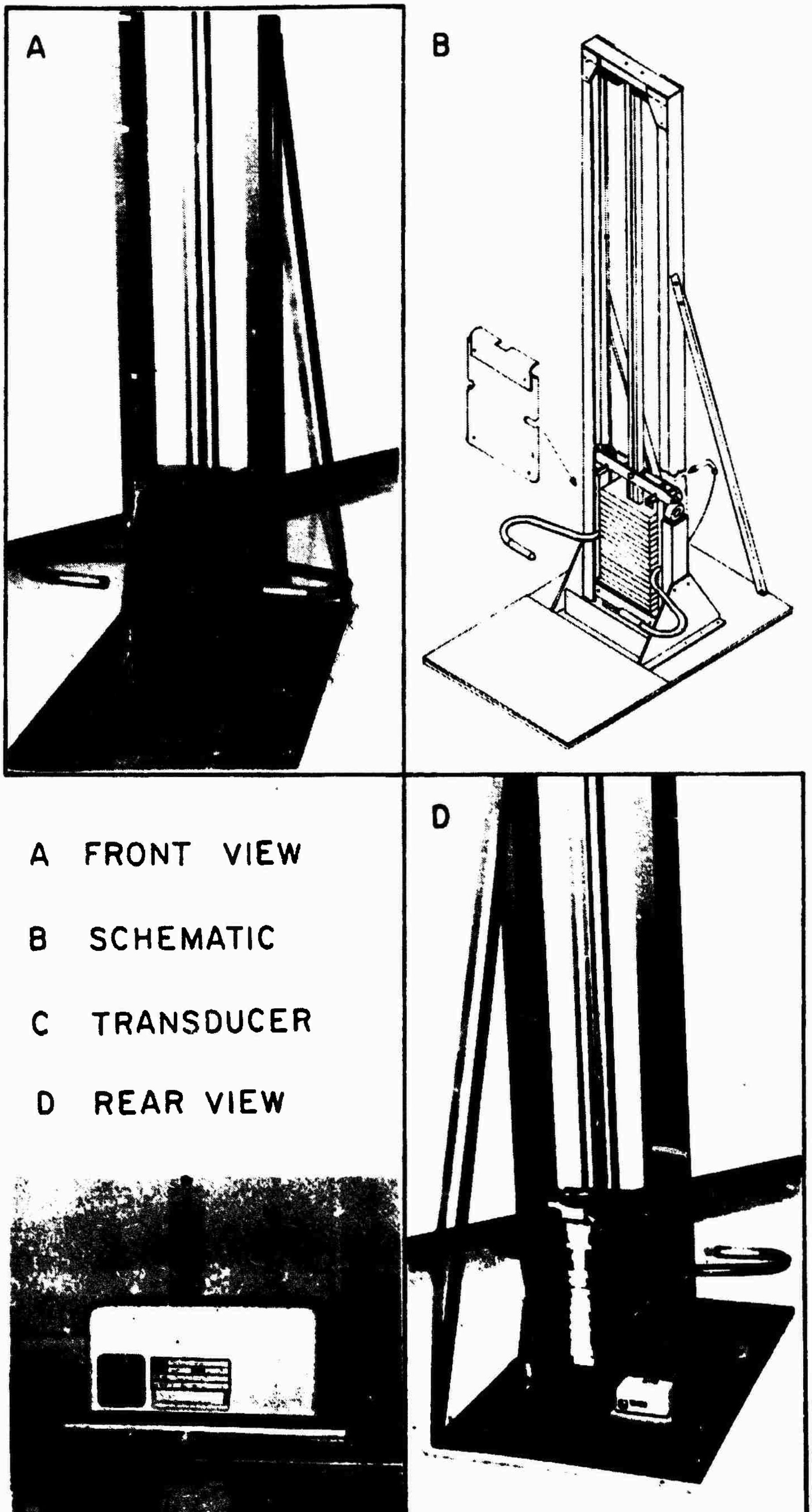
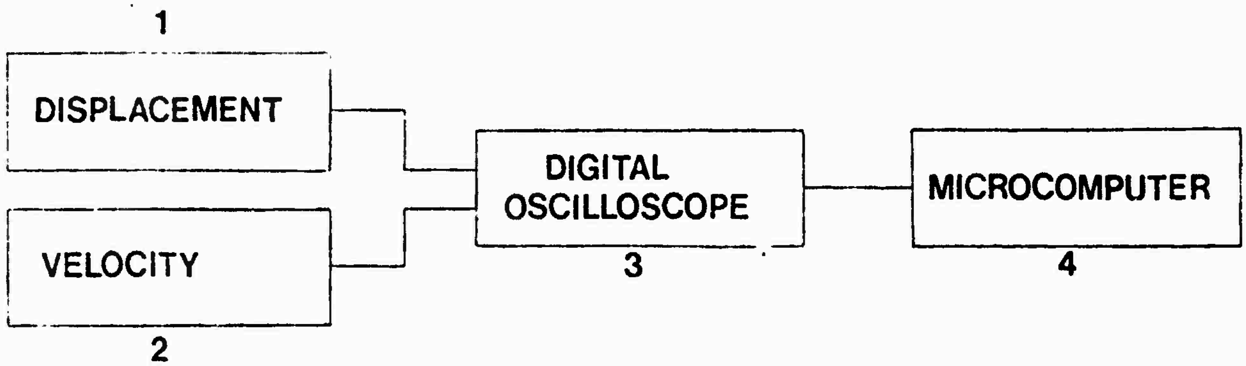
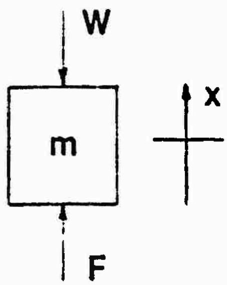


Figure B7.1. The Incremental Lifting Machine (ILM). Subject must raise armature to height of six feet in one smooth motion by using handles as shown in (A). Weights are incremented after successful lift (B). Displacement/speed transducer (C) is attached to armature to measure kinetic variables (D).

(A)



(B)



FREE BODY DIAGRAM OF MASS

DISPLACEMENT	x	
VELOCITY	$\dot{x}$	
		FILTER, DIFFERENTIATE, FILTER
ACCELERATION	$\ddot{x}$	
		$F = m\ddot{x} + W$
FORCE	F	
		$P = F\dot{x}$
POWER	P	

FIGURE B7.2. Data Reduction for Kinetic Variables. (a) Data pathway. (b) Free-body diagram of moving mass. Differentiation of velcoity given acceleration. Force is related to acceleration and mass by equation shown. Power is calculated from product of Force and Speed.

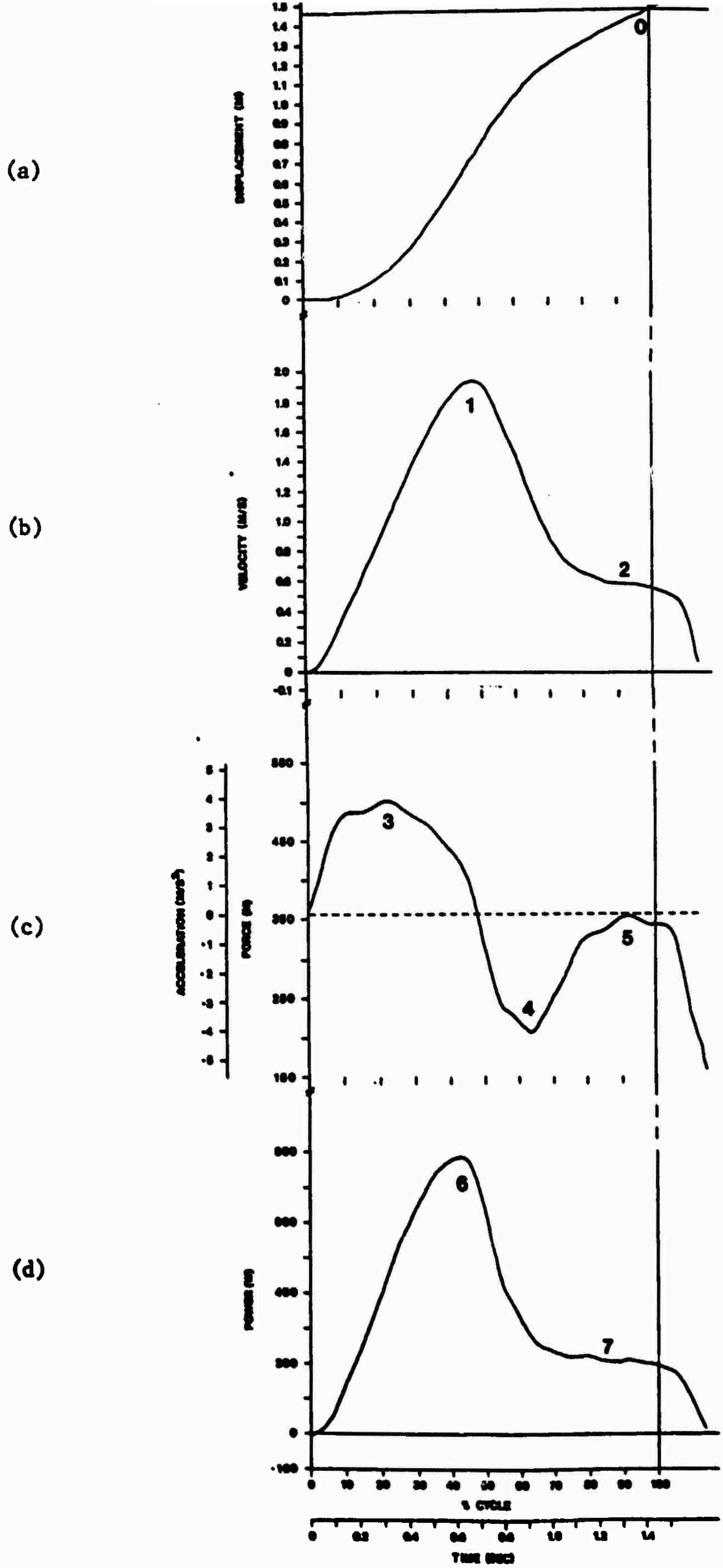


FIGURE B7.3. Kinetic Profiles. All four curves have the same ordinate with scales in seconds and in % of lift cycle. Seven events are noted. (a) Displacement; (b) Speed; (c) Acceleration and Force; (d) Power.

Force and acceleration are plotted together in Figure B7.3c. As indicated in the equation of Figure B7.2, these two variables are linearly related and therefore share the same temporal relationships. Events 3, 4 and 5 were found in these plots. Event 3 was the maximum force or acceleration which occurred at 20% to 30% of the lift. Event 4 was the minimum force or acceleration and occurred at the wrist-over manoeuver: the point at which the subject suddenly moved under the lifting bar. Event 5 was the final force or acceleration attained as the lift was completed.

Two peaks were observed in the power versus time curve of Figure B7.3d. Peak power occurred as Event 6, near 50% of the lift cycle. Peak 7 was the final power level occurring as the lift was completed. The power and velocity curves have similar shapes but the peaks of the power curve precede those of the velocity curve.

It is possible to identify each of these seven events in terms of the time at which they occur. Furthermore, each corresponding kinetic measurement can be recorded at each event time. For example, force and acceleration are recorded at Event 3. In addition, the time, displacement, speed, and power could also be recorded. These measurements are summarized in Figure B7.4. Here, each of the kinetic parameters is identified with each of the events. After eliminating those with no biomechanical significance, 37 variables remained which characterized a lift from the kinetic viewpoint. Also, average values for force, acceleration, power and speed were obtained.

B7.3. Data Reduction.

It is unlikely that all 37 variables are necessary to characterize a lift. To identify variables which were most important in this characterization, the method of principal components was used. The technique identifies variables most closely related to each other in groups of factors. Furthermore, it identifies factors which are unrelated to each other. By this, variables are grouped into meaningful factors which are independent and descriptive of the lift.

In this study, 132 males and females subjects underwent testing at the Halifax and Kingston sites. For each subject, the last successful ILM lift was used as the basis on which the kinetic variables were studied. Data, automatically acquired on an IBM PC microcomputer, were analyzed offline to identify the seven key lift events. These data were then organized into a data file which could be uploaded to the Queen's University Mainframe System. Using these data, the Statistical Package for Social Sciences Subroutine Sibrary program "FACTOR" was implemented to perform principal component analysis.

Certain judgments are required in selecting factors and variables which load on particular factors. These are outlined in any number of literature sources such as Harman (1976). In this analysis, variables were rejected if they loaded less than 0.3 on all factors or if they loaded more than 0.3 on more than one factor. Using these standard criteria,

EVENT	TIME	DISP	VEL	ACC	FORCE	POWER
0	**tmax** Time to Six Feet Sec.					
1	**t1** Time at Peak 1 Velocity S	**d1** Disp at Peak 1 Velocity m	**s1** Speed at Peak 1 Velocity m/s	**a1** Acc at Peak 1 Velocity m/s^2	**f1** Force at Peak 1 Velocity N	**p1** Power at Peak 1 Velocity Joules
2			**s2** Speed at Min 1 Velocity m/s			
3	**t3** Time at Peak 1 Acc/For S	**d3** Disp at Peak 1 Acc/For m	**s3** Speed at Peak 1 Acc/For m/s	**a3** Acc at Peak 1 Acc/For m/s^2	**f3** Force at Peak 1 Acc/For N	**p3** Power at Peak 1 Acc/For Joules
4	**t4** Time at Peak 2 Acc/For S	**d4** Disp at Peak 2 Acc/For m	**s4** Speed at Peak 2 Acc/For m/s	**a4** Acc at Peak 2 Acc/For m/s^2	**f4** Force at Peak 2 Acc/For N	**p4** Power at Peak 2 Acc/For Joules
5	**t5** Time at Peak 3 Acc/For S	**d5** Disp at Peak 3 Acc/For m	**s5** Speed at Peak 3 Acc/For m/s	**a5** Acc at Peak 3 Acc/For m/s^2	**f5** Force at Peak 3 Acc/For N	**p5** Power at Peak 3 Acc/For Joules
6	**t6** Time at Peak 1 Power S	**d6** Disp at Peak 1 Power m	**s6** Speed at Peak 1 Power m/s	**a6** Acc at Peak 1 Power m/s^2	**f6** Force at Peak 1 Power N	**p6** Power at Peak 1 Power Joules
7						**p7** Power at Peak 2 Power Joules
AVERAGE			**av vel** Ave. Vel. for Six Foot Lift m/s	**acc** Average Acc. m/s^2	**force** Average Force N	**power** Average Power Joules

FIGURE B7.4. Thirty seven variables used to define lift sequence on ILM. Each variable is recorded at the time indicated for an event. Variables with no significance have been removed. Also calculated are Averages for Speed, Acceleration, Force and POWER.

it was possible to identify variables comprising factors which described the ILM lift for these 132 subjects.

B.7.4. Results.

Five factors were identified which could account for 96% of the variance in the ILM kinetic data and were consistent for men and women. These are shown in Table B7.1 with variables which make up each of the factors. These showed astonishing consistency and were easily identified in terms of their biomechanical significance. The first factor represented force and power variables at various points throughout the lift. F1, F3 and F6 were the forces at peak speed, peak force and peak power respectively. P1 represents the power at peak speed, while FORCE is a measure of the average force throughout the lift. This factor apparently measured the dynamic force and power exhibited by a particular subject during the lift cycle.

The second factor involved temporal relationships and could be termed the temporal or timing factor. T1, T4 and T6 represent the time at peak speed, at wrist-over, and peak power. This factor appears to quantify the timing between these three events within the lift.

Factors 3, 4 and 5 identified specific points in the lift rather than attempting to describe the entire lift sequence. Factor 3 identified the force and power at Event 4, the wrist-over over manoeuver. This is the point at which most lift failures occurred. Factor 4 identified the time and displacement when the peak force occurred. This suggested the importance of the lower body in the lift, since this peak occurred during the maximum extension rate for the lower limb. Finally, Factor 5 included variables which described displacement at Event 4 and Event 5. These displacements are representative of the stroke of the arm during the upper body phase of the lift.

B7.5. Factor Scores.

Rather than consider all of the variables listed within the factors, it is possible to combine these data in terms of five Factor Scores. These scores are designed so that for a population sample, the mean of each Factor Score is zero and its variance unity.

Examining the distribution of Factor Scores revealed that they were normally distributed in most cases. An exception was Factor 1 which showed a bimodal distribution. This may be related to the distinct difference in men and women with regard to ability to generate force and power since these variables dominate the Factor Score. Thus, the two peaks may have represented the two sexes. All other Factor Scores were distributed without such a distinction.

TABLE B7.1. Factor Structure for the ILM Lifts for All Subjects (Kingston and Halifax Combined, n=132).

FACTORS	CODE	CODE DEFINITION
FACTOR 1	F1	Force at Peak Speed
	F3	Force at Peak Force
	F6	Force at Peak Power
	P1	Power at Peak Speed
	FORCE	Average Force
FACTOR 2	T1	Time at Peak Speed
	T4	Time at Wrist Change-Over Manoeuvre
	T6	Time at Peak Power
FACTOR 3	F4	Force at Wrist Change-Over Manoeuvre
	P4	Power at Wrist Change-Over Manoeuvre
FACTOR 4	T3	Time at Peak Force
	D3	Displacement at Peak Force
FACTOR 5	D4	Displacement at Wrist-Over Manoeuvre
	D5	Displacement at Terminal Force

B7.6. Correlation with Task Scores.

The objective of refined ILM measurements was to determine whether or not they had a higher correlation to task performance than raw ILM scores. Previous work indicated that such would be the case if a large lifting component were involved with the task.

To examine correlation, three processes were used. In the first, simple correlation between factor scores and task performance was tested. Second, multiple linear regression was used in which the Factor Scores were forced into the equation of best fit. Finally, ILM factor scores were included in the pool of EXPRES and laboratory test data for stepwise regression analysis.

The results of simple correlation are shown in Table B7.2. While significant correlations existed for several of the factors with task scores, none had high regression coefficients. The multiple linear regression (in which Factor Scores were forced) had similar results as shown in Table B7.3. While high correlations existed, the regression coefficient was low. This suggests that Factor Scores represent underlying physical principles which guide the relationship but also reveals difficulty in measuring either the Factor or the task performance.

The relationship between Factor Scores and task scores has one additional piece of information. The normalization method for factor scores takes away any bias due to the scaling of particular variables. As a result, the magnitude of coefficients in the correlation equations indicate the relative importance of each factor. By this, it can be shown that each task is affected differently by different factors.

Observing Table B7.3 indicates that all tasks were most strongly affected by Factor Score 1. This likely reflected the force/power variables of the lifting components of the tasks. For females, other Factor Scores were weighted strongly in the correlation equations. Factor Score 3 was significant in all three tasks. This corresponds to the wrist-over manoeuver in the ILM lift. Such an observation is consistent with the high simple correlation between these task scores and Grip Strength Measures.

For males, Factor Score 5 was most often included with Factor Score 1 in the correlation equation. This factor, which related to upper body movement during a lift, suggests its importance in the execution of these tasks by male subjects. Interestingly, Factor Score 5 always weighted lowest for females, indicating a sex-based difference in technique for the tasks.

The introduction of ILM kinetic profile data into the general pool for stepwise multiple linear regression did not influence the ability to predict task performance. As shown in Table B7.4, only one case revealed a Factor Score which entered the multiple linear regression equations. This was the Entrenchment Dig for females in which Factor Score 2 appeared. In no case did the regression coefficient increase significantly, even when Factor Scores were forced into the regression equation.

TABLE B7.2. Simple Correlation Coefficients for ILM Factor Scores vs Task Scores. Only Coefficients with Significance p < .05 are Shown.

FACTOR	FEMALES			MALES			
	LAND CARRY	LO-HI CRAWL	DIG	LAND CARRY	LO-HI CRAWL	DIG	SEA CARRY
FACTOR 1		-.347 (.028)	-.364 (.022)		-.163 (.050)		-.338 (.000)
FACTOR 2							
FACTOR 3							
FACTOR 4							
FACTOR 5				-.201 (.021)			

TABLE B7.3. Unstandardized Coefficients in Multiple Linear Regression Equations for ILM Factor Scores Versus Task Scores.[1]

FACTOR	FEMALES			MALES			
	LAND CARRY	LO-HI CRAWL	DIG	LAND CARRY	LO-HI CRAWL	DIG	SEA CARRY
FACTOR 1	-22.89	-51.33	-18.35	-0.44	-2.84	-3.66	-12.34
FACTOR 2	-.9.93	14.03	-8.04	--	--	--	1.00
FACTOR 3	10.89	12.55	6.62	--	--	--	-0.58
FACTOR 4	-32.04	--	-16.15	--	--	--	-0.11
FACTOR 5	-1.64	--	-2.56	0.77	--	-2.11	0.16
CONSTANT	8.80	83.95	65.79	15.92	77.84	53.37	130.56
R	0.597	0.477	0.634	0.217	0.163	0.208	0.341
R-SQUARED	0.356	0.227	0.401	0.050	0.027	0.043	0.116
F	2.768	2.648	3.352	2.467	2.748	2.270	2.550
p(1-tailed)	0.02	0.035	0.010	0.045	0.050	0.050	0.017

[1] Note: Factor correlation coefficients were low, but in all cases one-tailed significance was less than 5 %. Factors indicated by -- did not enter the regression equations.

Table B7.4A. Multiple Linear Correlations Including ILM Kinetic Variables and Factor Scores (Males).

	VARIABLES	R VALUE (Significance)
Stretcher Carry (n=60)		
(i) Unforced Model	1. LEG Erg. %Fatigue	0.325
	2. Combined Endurance Grip	(0.002)
(ii) Forced Model	1. Factor Score 5	0.458
	2. LEG Erg. Power	(0.000)
	3. LEG Erg. %Fatigue	
	4. Combined Endurance Grip	
Low-High Crawl (n=61)		
(i) Unforced Model	1. MVO_2	-0.279
		(0.002)
(ii) Forced Model	1. Factor Score 1	0.295
	2. Pushups	
	3. MVO_2 (Step Test)	(0.007)
Entrenchment Dig (n=58)		
No models of significance $p < .05$		
Sea Stretcher Carry (n=22)		
(i) Unforced Model	1. LEG Erg. Power	0.505
	2. ARM Erg. Power	(0.000)
	3. Flexed Arm Hang	
(ii) Forced Model	1. ILM Mass (6-foot)	0.517
	2. ARM Erg. Power	(0.000)
	3. LEG Erg. Power	
	4. Flexed Arm Hang	
	5. Factor Score 5	

Table B7.4B. Multiple Linear Regression Correlations Including ILM Kinetic Variables and Factor Scores (Females).

		VARIABLES	R VALUE (Significance)
Land Stretcher Carry (n=30)			
(i)	Unforced Model	1. Combined End. Grip 2. Flexed Arm Hang 3. Leg Erg. Fatigue	0.699 (0.003)
(ii)	Forced Model	1. Combined End. Grip 2. Flexed Arm Hang	0.625 (0.000)
Low-High Crawl (n=30)			
(i)	Unforced Model	1. Leg Erg. Power	0.451 (0.005)
(ii)	Forced Model	1. Factor Score 1 2. Factor Score 2 3. Situp 4. Leg Erg. Power 5. Flexed Arm Hang	0.581 (0.027)
Entrenchment Dig (n=30)			
(i)	Unforced Model	1. Combined Grip Strength 2. Combined End. Grip 3. Flexed Arm Hang 4. T4 (Factor Score 2)	0.811 (.000)
(ii)	Forced Model	1. Factor Score 1 2. Combined Grip Streng 3. Combined End. Grip 4. Flexed Arm Hang 5. T4 (Factor Score 2)	0.796 (.000)
Sea Stretcher Carry			
		Insufficient Data	

B7.7. Interpretation and Conclusion.

The identification of five factors with biomechanical significance for the ILM lift is novel and of potential importance. While it did not improve the ability to predict tasks as undertaken in this study, it did suggest underlying reasons for this. In previous studies it was found that for a purely lifting task, these data show high correlations. The lack of correlation in the results of the present study suggests that tasks chosen for analysis had relatively little lifting component. This conclusion differs somewhat from other reports from DCIEM in which several studies have indicated that up to 75% of common military tasks have a significant lifting component.

A second observation is the relationship between Factor Scores from the ILM and several task scores. In most tasks, Factor 1, the force/power factor was dominant. However, for females, all other Factor Scores were also significant. This suggests that in not all cases was strength the major component in lifting aspects of the performance of the task.

SECTION B8.

LIST OF REFERENCES

SECTION B8.

List of References

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APPENDIX A

M.P.F.S. Contract Proposal

DEVELOPMENT OF A TEST BATTERY FOR MINIMUM PHYSICAL FITNESS STANDARDS FOR USE BY THE CANADIAN FORCES

submitted by

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to

DEFENCE AND CIVIL INSTITUTE
OF ENVIRONMENTAL MEDICINE

SUBMISSION DATE: April 1, 1985

BACKGROUND

The applied Physiology Section at DCIEM has been tasked by the Director of Physical Education and Recreation amenities (DPERA) to help develop minimum Physical Fitness Standards (MPFS) for the Canadian Forces (CF). These standards are to apply to all CF pers nel, regardless of trade, classification, age, or sex. They are to be based on seven common tasks defined by DPERA with input from various NDHQ Directorates and units such as the CF Survival School. The development of MPFS is based on the precept that all personnel of the Canadian Forces may be called upon to perform such tasks in times of emergency. Viewed from this perspective, the state of "constant readiness" is an important objective to be pursued by the military and physical fitness is a vital component of such readiness.

Specific Purpose of this Contract

The purpose of this contract is to identify and quantify those components of physical fitness involved in performing the seven common tasks. The information will provide the basis for development of field tests of physical fitness that might objectively measure one's ability to perform the common tasks.

WORK STATEMENT

The overall work plan is divided into two phases. Phase 1 meets short term objectives by providing a scientific basis for defining the MPFS for the CF. Phase 2 involves the design and verification of the MPFS specifically. This contract is intended to cover Phase 1 only.

Protocol and budget for Phase 2 will be prepared later based on data collected in the first study.

Design and Validation
of Task Performance Ratings

The primary objective of Phase 1 is to develop a scientific method by which task performance may be rated. The present principles of rating methods for task performance such as stretcher carry, fire fighting, or surveillance activities, involve a simple pass or fail. In order to improve a model for predicting performance in a task, it is first required to first establish a technique of ranking the performance on some scale.

The work plan summary is shown in Table 1. A literature survey will enable the designation of critical tasks from the list of seven common tasks shown in Annex A. Field observations of these tasks will be untertaken at CFB Kingston and CFB Halifax. Biomechanical and Physiological assessment of these observations will be undertaken at Queen's. With additional testing on volunteer subjcets, the design of standard task protocols and performance rating methods will be possible. A second field study will be undertaken in which performance rating and some fitness testing will be performed on military personnel. Subsequent data analysis will indicate the range of performance within these personnel and indicate the correlation between fitness scores and performance. The degree of correlation is difficult to predict, but an interim report documenting the findings of Phase 1 will be prepared for October 30, 1985.

Table 1. WORKPLAN SUMMARY FOR PHASE 1

TITLE	OBJECTIVES	SITE	STARTING DATE	COMPLETION DATE
1.1 LITERATURE SURVEY	1. Study of #3 #4 & #6 as critical tasks	Q	15 Apr 85	30 May 85
1.2 FIELD OBSERVATIONS	1. Observation of 3a & 6	K	15 Apr 85	19 Apr 85
	2. Observation of 3b & 4	H	29 Apr 85	3 May 85
1.3 BIOMECHANICAL & PHYSIOLOGICAL ANALYSIS OF TASKS	1. Determine sub-tasks from literature & field study			
	2. Design standard task protocols	Q	3 May 85	5 Jul 85
	3. Establish performance rating methods			
1.4 FIELD STUDY	1. Performance rating (n=24) for tasks #3a & #6	K	8 Jul 85	12 Jul 85
	2. Performance rating (n=24) for tasks #3b & #4	H	15 Jul 85	19 Jul 85
1.5 DATA ANALYSIS	1. Correlation of performance ratings, subtask scores, and EX-PRES evaluation	Q	22 Jul 85	28 Sep 85
1.6 DOCUMENTATION	1. Preparation of Interim report	Q	30 Sep 85	28 Oct 85

Q : QUEEN'S UNIVERSITY AT KINGSTON

K : CANADIAN FORCES BASE AT KINGSTON

H : CANADIAN FORCES BASE AT HALIFAX

1.1 Literature Survey. A Critical Task is one of the seven common tasks of Annex A which is likely to require a high fitness component. At this time, we have chosen tasks 3, 4 and 6 as the Critical Tasks from this list. A literature survey is required in order to validate that this has some scientific basis. In particular, we wish to examine studies of the other tasks to ensure that a large fitness component has not been previously documented.

1.2 Field Observations. Field trips to CFB Kingston and CFB Halifax will be undertaken to observe male and female military personnel performing tasks 3, 4 and 6. During these tests, subjects will be videotaped performing their regular duties under the direction of their supervisors. This information will be subsequently used in the biomechanical assessment of these tasks.

Other biomechanical measurements include the assessment of loading on the subject. This will be determined using spring scales and weigh scales where appropriate. Physiological measurements will be limited to an estimate of heart rate during various activities.

1.3 Biomechanical and Physiological Analysis of Tasks. In order to illustrate the protocol to be used in the analysis of tasks, Task 3A (80 kilogram stretcher carry for 1 kilometer in 20 minutes) will be used as an example. Having observed this task at CFB Kingston, and reviewing the subsequent film, it will be possible to break this task into sub-tasks. These are outlined in Figure 1. Suggested here are the sub-tasks of lifting 40 kilograms to standing, hold with arms

TASK NO. 3A: 80 Kg STRETCHER CARRY (1 Km in 20 Minutes)

SUB-TASKS:

LIFT TO STANDING; HOLDING WITH ARMS EXTENDED: WALKING WHILE CARRYING.... OTHERS.

VARIABLES:

1.0 PHYSICAL & ANTHROPOMETRIC	2.0 EXPRESS BATTERY	3.0 MUSCLE GROUPS	4.0 COORDINATED MUSCLE ACTION	5.0 AEROBIC POWER
1.1 Height	2.1 Sit-Ups	3.1 Grip	4.1 ILM Max	5.1 Max O_2 Consumption
1.2 Weight	2.2 Push-Ups	3.2 Arm	4.2 ILM Timed	5.2 Pulmonary Ventilation
1.3 % Body Fat	2.3 Running	3.3 Shoulder	4.3 ILM Submax	5.3 Max Heart Rate
⋮	⋮	⋮		⋮

6.0 ANAEROBIC POWER ....(OTHERS)

6.1 Max Lactate
6.2 Wingate Test
6.3 Margaria Test
⋮

IV. ESTABLISHMENT OF:

MINIMUM PERFORMANCE FITNESS STANDARDS:

FIELD TEST FORMAT

III. CORRELATION MATRIX

-With Subjects' Data From BOTH the Laboratory and Field Testing being correlated by Regression Analysis.

SUCCESSFUL TASK PERFORMANCE

-And the Operational Variables which Accounted for Successful Performance.

II. FIELD TEST PERFORMANCE

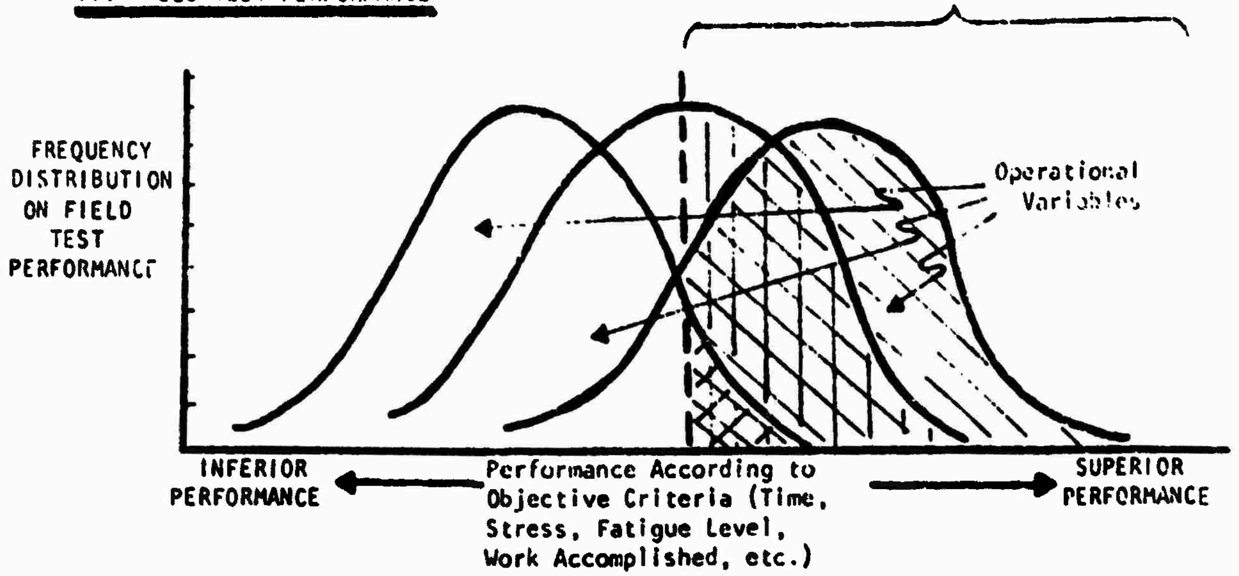


FIGURE 1. SPECIFIC TASK MODEL: NO. 3A STRETCHER CARRY

extended and walking while carrying. Other sub-tasks may be identified on the basis of film analysis. By combining the elements of the subtasks which are common to all personnel performing the task in as many conditions as observed, it will be possible to design a standard test protocol (STP). The STP will be a rigorously defined method of combining the sub-tasks to perform a simulation of the actual task. This serves to establish the magnitude of work in each sub-task, the duration of the sub-task, and its temporal relationship to other sub-tasks.

Having established these relationships, each sub-task may then be dissected into a series of fitness factors. These represent factors which may limit the performance of the sub-task. It is important to identify this chain. That is, fitness factors limit sub-task performance and sub-task perormance limits overall task performance. The list of variables which relate to Task 3A is shown in Table 2.

A series of experiments will be performed on volunteers to validate these biomechanical and physiological assessments. First, the sub-task which limits overall task performance will be identified. Next, the physiological and biomechanical variables which limit sub-task performance will be identified. In the example given, the limiting sub-task may well be the ability to hold 40 kilograms for 20 minutes. As such, the fatiguing of wrist grip muscles may be the limiting physical variable underlying the ability to perform the task. Thus, the rate at which

Table 2.

TASK 3A REQUIREMENTS :	80KG. STRETCHER CARRY FOR 1 KM 20 MIN
PHYSIOLOGICAL/BIOMECHANICAL REQUIREMENTS	POTENTIAL LIMITING FACTOR THAT MAY CAUSE FAILURE OF THIS COMMON TASK.
<1.0> PHYSICAL & ANTHROPOMETRY	
<1.1> HEIGHT	
<1.2> LEAN BODY MASS	
<1.3> WEIGHT	
<1.4> OTHERS	
<2.0> EXPRESS TESTS	
<2.1> SIT-UPS	
<2.2> PUSH-UPS	
<2.3> OTHERS	
<3.0> MUSCLE GROUPS REQUIRED	
<3.1> GRIP OR WRIST	
<3.2> ARM FLEXORS OR EXTENSORS	
<3.3> SHOULDER MUSCLES	
<3.4> BACK MUSCLES	
<3.5> ABDOMINAL MUSCLES	
<3.6> LOWER LEG FLEXORS	
<3.7> LOWER LEG EXTENSORS	
<4.0> COORDINATED MUSCLE ACTIONS	
<4.1> MAXIMUM ILM LIFT	
<4.2> TIMED ILM LIFT	
<4.3> SUBMAXIMAL ILM LIFT	
<4.4> POWER ILM LIFT	
<5.0> AEROBIC POWER	
<5.1> MAXIMUM OXYGEN CONSUMPTION	
<5.2> PULMONARY FUNCTIONS	
<5.3> MAXIMUM HEART RATE	
<5.4> MAXIMUM BLOOD LACTATES	
<5.5> STROKE VOLUME	
<5.6> OXYGEN EXTRACTION	
<6.0> ANAEROBIC POWER	
<6.1> WINGATE TEST	
<6.2> MARGARIA STEP TEST	
<6.3> BLOOD LACTATE	
<6.4> OTHER FACTORS	
<7.0> OTHER FACTORS	
<7.1> FLEXIBILITY	
<7.2> PERCEIVED EXERTION	
<7.3> ANXIETY	
<7.4> TEMPERATURE READINGS	
<7.5> OTHER FACTORS	

these muscles fatigued would be a measure of a persons ability to perform the task. In addition, the evaluation of task performance could also be based on how much fatigue took place while a subject was actually performing the task.

The end result of these analyses will be the design of standard test protocols, the identification of sub-tasks and fitness factors which limit performance of the standard test protocol, and a method by which performance can be rated.

1.4 Field Study. At this stage, a preliminary design for fitness assessment will be prepared. This will include the EX-PRES test and several additional tests as indicated from the anlaysis of Part 1.3. Also available will be standard task protocols for each of tasks 3, 4 and 6 and methods by which the performance can be rated. In the field studies at CFB Kingston and CFB Halifax, military personnel will undergo fitness evaluation and STP's for tasks 3, 4 and 6. At each base, twelve male and twelve female subjects will be studied.

1.5 Data Analysis. Using methods previously established for OPSS, correlation of fitness scores and performance ratings will be undertaken. This will use techniques of simple correlation, multivariate correlation, and the method of principal components. Statistical results will include an identification of those fitness factors most indicative of task performance. However, it is difficult to predict the amount of scatter which will be present in these data.

1.6 Documentation. A interim report will be prepared by October 30, 1985. This will include a summary of findings for Phase 1, appropriate recommendations regarding minimum physical fitness standards, and detailed protocol for Phase 2.

ANNEX A

List of The Seven Common Tasks

LIST OF THE SEVEN COMMON TASKS

1. Operate his/her personal weapon

   Complete infantry annual weapons test "Shoot to Live", CFP 318 (6) to a pass standard.

2. Function effectively in an NBCW environment

   In individual protective equipment and using mask and in a high heat environment, perform normal duties for 8 h slowly to meet objective of preventing physical breakdown associated with heat stress and isolation of NBCW posture. (Note, normal duties to be defined).

3. Perform first aid and casualty evacuation

   a. Two person team, using a stretcher, will evacuate a normal person (80 kg) across rough terrain a distance of 1 km within 20 min.

   b. Two person team will move a stretcher with 80 kg person, while in fire-fighting gear, a horizontal distance of 25 m followed by moving the stretcher up and down one deck in 10 min.

4. Perform fire-fighting duties

   In fire-fighting gear and using breathing apparatus and in varying temperatures, control 50 ft (15 m) of charged hose for 30 min climbing and descending one deck.

5. Execute survival and search and rescue techniques

   In environmental clothing, walk at slow speed (80-100 paces per minute) over all kinds of terrain for 8 h.

6. Perform general security duties

   The following is a verbatim description of "common soldiering tasks" proposed for US infantry (note: mixture of imperial and metric units). These items are tentatively considered representative of security duties.

   a. March 8 km (2 h): personnel are placed in march formation, light packs and carrying weapons; they are allowed to establish their own pace while marching on roads over level or slightly rolling terrain.

b. Dig emplacement (45 min): Each person digs a one-man foxhole to a depth of 18 ins in soil of medium firmness with no rocks or large roots using the entrenching tool. The foxhole is approximately 6 ft long and 2 ft wide.

c. Lift and carry (10 min): The soldier lifts and carries a 50 lb bag of sand for 50 m. The bag is set down and the person moves back to the starting line where the procedure is repeated until 8 bags are moved.

d. Low and high crawl (90 sec): The soldier does the low crawl (all body parts close to the ground) for 30 m, turns 180 degrees and does the high crawl (on hands and knees) for 45 m.

e. Rush (25 sec): The soldier sprints 75 m carrying weapon with two intermediate stops of 2 sec each behind cover barriers at the 25 m and 50 m marks.

7. <u>Live and work in his/her applicable environmental condition</u>

As for 6, but with NBCW clothing.

ANNEX B

Workplan Summary for Phase 2

ANNEX B : WORKPLAN SUMMARY FOR PHASE 2

TITLE	OBJECTIVES	SITE	STARTING DATE	COMPLETION DATE
2.1 BIOMECHANICAL & PHYSIOLOGICAL TESTING	1. Detailed laboratory testing of 48 subjects with performance ratings in Phase 1	Q	4 Nov 85	24 Jan 86
2.2 DATA ANALYSIS	1. Correlation of TPR to physiological & biomechanical measurements	Q	27 Jan 86	14 Mar 86
2.3 TEST DESIGN	1. DESIGN M.P.F.S.	Q	17 Mar 86	2 May 86
2.4 FIELD STUDY	1. M.P.F.S. & T.P.R. (n=50) for tasks #3a & #6	K	5 May 86	16 May 86
	2. M.P.F.S. & T.P.R. (n=50) for tasks #3b & #4	H	19 May 86	30 May 86
2.5 DATA ANALYSIS	1. Correlation M.P.F.S. to T.P.R.	Q	2 Jun 86	11 Jul 86
2.6 DOCUMENTATION	1. Preparation of final report	Q	14 Jul 86	29 Aug 86
2.7 MANUAL PREPARATION	1. Preparation of M.P.F.S. Operations Manual	Q	2 Sep 86	31 Dec 86

Q : QUEEN'S UNIVERSITY AT KINGSTON

K : CANADIAN FORCES BASE AT KINGSTON

H : CANADIAN FORCES BASE AT HALIFAX

APPENDIX B

Subject Distribution Based on EXPRES

TABLE APPB.1. Kingston Subject Distribution based on EXPRES.

A. Maximal Oxygen Consumption

Population	20-29	yrs	30-39	yrs	40-49	yrs	50-59	yrs
Distribution	men	women	men	women	men	women	men	women
Excellent >97%	6	1	1		3		1	
Good 75%-96%	13	7	7	2	1		1	
Minimum 25%-74%	18	6	4	1	1			
Below Min. 4-24%	2	1						
Poor <3%								

B. Combined Hand Grip Scores

Population	20-29	yrs	30-39	yrs	40-49	yrs	50-59	yrs
Distribution	men	women	men	women	men	women	men	women
Excellent >97%	5	3	3	1	2		1	
Good 75%-96%	17	7	6	2	3		1	
Minimum 25%-74%	16	5	3		1			
Below Min. 4-24%								
Poor <3%								

C. Push-ups

Population	20-29	yrs	30-39	yrs	40-49	yrs	50-59	yrs
Distribution	men	women	men	women	men	women	men	women
Excellent >97%	12	11	6	1	3		1	
Good 75%-96%	16	4	4	2	2			
Minimum 25%-74%	12		2		1		1	
Below Min. 4-24%								
Poor <3%								

D. Sit-ups

Population Distribution	20-29 yrs men	20-29 yrs women	30-39 yrs men	30-39 yrs women	40-49 yrs men	40-49 yrs women	50-59 yrs men	50-59 yrs women
Excellent >97%	7	5	3		1		1	
Good 75%-96%	12	6	6	1	2		1	
Minimum 25%-74%	17	4	2	2	3			
Below Min. 4-24%	4		1					

TABLE APPB.2. Halifax Subject Distribution based on EXPRES.

A. Maximal Oxygen Consumption

Population Distribution	20-29 yrs men	20-29 yrs women	30-39 yrs men	30-39 yrs women	40-49 yrs men	40-49 yrs women	50-59 yrs men	50-59 yrs women
Excellent >97%		1						
Good 75%-96%	6	6	5	1	2			
Minimum 25%-74%	7	2	7	1	3			
Below Min. 4-24%	1		1		1			
Poor <3%			1					

B. Combined Hand Grip Scores

Population Distribution	20-29 yrs men	20-29 yrs women	30-39 yrs men	30-39 yrs women	40-49 yrs men	40-49 yrs women	50-59 yrs men	50-59 yrs women
Excellent >97%		1	1	1	1			
Good 75%-96%	6	7	4					
Mimimum 25%-74%	7	1	5	1	4			
Below Min. 4-24%	1		1		1			
Poor <3%	1							

C. Push-ups

Population Distribution	20-29 yrs men	20-29 yrs women	30-39 yrs men	30-39 yrs women	40-49 yrs men	40-49 yrs women	50-59 yrs men	50-59 yrs women
Excellent >97%	2	4	1	1	1			
Good 75%-96%	3	5	6	1	2			
Minimum 25%-74%	8		3		2			
Below Min. 4-24%	1		2					
Poor <3%								

D. Sit-ups

Population Distribution	20-29 yrs men	20-29 yrs women	30-39 yrs men	30-39 yrs women	40-49 yrs men	40-49 yrs women	50-59 yrs men	50-59 yrs women
Excellent >97%	1	2						
Good 75%-96%	2	4	3	2	1			
Minimum 25%-74%	8	2	5		3			
Below Min. 4-24%	4	1	4		2			
Poor <3%								

APPENDIX C

Details of Test Methodologies

Appendix C

Details of Test Methodologies

Following are detailed descriptions of the physical and physiological test battery administered to each subject including physical data (height, weight, and percent body fat), fitness data (as determined by the Canadian Forces EXPRES test battery) and six additional performance tests which the present investigators determined were pertinent to the physical tasks outlined for the Canadian Forces.

Physical Characteristics of Subjects.

1. Body Mass. Employing a Dalto weight scale, subject's body mass was determined to the nearest 0.1 kg.

2. Height. Employing the Dalto height scale and adjustable armature, height was recorded to nearest 0.5 cm.

3. Percent Body Fat Determined from Skin Fold Measurements. Four sites were measured-the triceps, biceps, subscapular and supra-iliac iliac skinfolds.

Equipment: skinfold caliper

Procedure: Grasp the skinfold beteween the thumb and index finger 1 cm above and below the site and apply firm pressure. Lift the skinfold. Apply caliper jaws at right angles to the prescribed site. Release the spring handles fully but support the weight of the calipers in the hand. Read the measurement after the full pressure of the caliper jaws has been applied and the drift of the needle has ceased. Record to the nearest 0.5 mm. Repeat the measurement. If the difference is greater than 2 mm, take a third measure and record the mean of the closest pair.

Triceps Skinfold: Measure the back of the unclothed pendent right arm at a level midway between the tip of the acromion and the tip of the elbow, with the forearm flexed at an angle of 90 degrees. Lift the skinfold parallel to the long axis of the arm. Ask the subject to lower the forearm, then apply the calipers to the site.
Biceps Skinfold: Measure the front of the pendent right arm over the biceps, at a level midway between the acromion and the tip of the elbow. Lift the skinfold parallel to the axis of the upper arm.
Subscapular Skinfold: With the subject standing, measure about 1 cm below the angle of the right scapula. Lift the skinfold so that its crease runs at an angle of about 45 degrees downward from the spine.
Supra-iliac Skinfold: Measure 3 cm above the supra-iliac crest, with the fold running parallel to the crest.

Physical Fitness Determination.

-see Canadian Forces EXPRES Handbook for details.

Additional Performance Tests.

Prediction of Maxiaml Aerobic Capacity.

Equipment: Mechanically braked bicycle ergometer
Metronome (set so that a person following its beat will be pedalling at 50 revolutions per minute)

Directions:

1. Set the work load of the bicycle ergometyer so that the target heart rate while pedalling at 50 revolutions per minute will be between 140 and 160 beats per minute. (The work load setting is usually between 450 and 900 kgm and depends on the level of aerobic fitness, age, sex, etc. of the subject.)

2. Pedal for 6 minutes, counting heart rate (by palpitation) over the last 15 seconds of each minute. (Then multiply by 4 to obtain the number of beats per minute.) After the second or third minute, you may have to adjust the ergometer workload so that the target heart rate (140 to 160 beats per minute) is achieved. The particular workload is recorded.

3. Over the final 3 minutes of this 6-minute test, the heart rate remains constant, between 140 and 160 beats per minute. This average, steady heart rate is used to predict aerobic fitness according to the Astrand-Rhyming nomogram. (see Appendix G) Record the heart rates, in beats per minute.

Wingate Tests: Leg and Arm Ergometer Power Tests.

The Wingate tests are maximal performance measures of an individual's anaerobic power. It requires an all out effort on a stationary cycle ergometer for 30 s. The subject must be highly motivated to determine his/her maximal score.

Equipment: Monark cycle ergometer
Monark arm ergometer
Commodore 64 microcomputer, printer, monitor program
cassette and tape recorder
co-axial cable with BNC connector

Warm-up:

TABLE APPC.1. Ergometer Settings According to Body Mass.

Subject Body Mass (kg)	Leg Erg. Workload (kp)	Arm Erg. Women (kp)	Workload Men (kp)
40	2.6	1.9	2.4
42	2.7	2	2.6
44	2.8	2.1	2.7
46	2.9	2.2	2.8
48	3.1	2.3	2.9
50	3.2	2.4	3.1
52	3.3	2.5	3.2
54	3.5	2.6	3.3
56	3.6	2.7	3.4
58	3.7	2.8	3.5
60	3.8	2.9	3.7
62	4	3	3.8
64	4.1	3.1	3.8
66	4.2	3.2	4
68	4.4	3.3	4.1
70	4.5	3.4	4.3
72	4.6	3.5	4.4
74	4.7	3.6	4.5
76	4.9	3.6	4.6
78	5	3.7	4.8
80	5.1	3.8	4.9
82	5.2	3.9	5
84	5.4	4	5
86	5.5	4.1	5
88	5.6	4.2	5
90	5.8	4.3	5
92	5.9	4.4	5
94	6	4.5	5
96	6.1	4.6	5
98	6.3	4.7	5
100	6.4	4.8	5

The warm-up procedure for the leg ergometer test will consist of performance of the Astrand-Rhyming Test. A warm-up for the arm ergometer test will be accomplished through the ILM testing procedure. It is important that the subject be allowed a brief exposure to the arm ergometer at sub-maximal RPM's and workload.

Method:

a) Starting Position - The seat should be adjusted to a comfortable height on the cycle ergometer (i.e., knee in extended position approximately 15 degrees with toe clips utilized). A seat belt must be secured around the hips for arm ergometer testing.

b) Computer - The computer will prompt the tester for relevant subject information as listed below. Type in the requested information, pressing the <RETURN> key after each input.

NAME
SOCIAL INSURANCE NUMBER (SIN)
Workload: determined from the attached weight/workload table
Flywheel Circimference: 6 for the leg ergometer 2.4 for the arm ergometer

c) Instructions - A subject should have the nature of the test outlined, and be informed the he/she must cycle as fast as possible for the entire test and not to preserve strength or pace him/herself. As well, he/she must remain seated throughout.

d) Protocol - On the command 'start', the subject will begin cycling at maximum speed. The load must be applied within 4 s. of the onset of cycling. When the predetermined load has been reached, an assistant will press <RETURN> on the computer to start the 30 s. test.

e) Motivation - Verbal encouragement is beneficial. The last 5 s. of the test should be counted down as it appears on the screen.

f) Test Completion and Cool Down - At the end of the test, the load is quickly reduced to minumum resistance and the subject continues to cycle at his/her own rate, or in the case of the arm ergometer to cease cycling altogether but remain seated. This is important to prevent the pooling of blood. The subject may feel some nausea and should be allowed to cycle until he/she feels recovered (i.e., at least 2-3 minutes or until the heart rate decreases to <120 beats/min.).

Endurance Grip Hold.

Equipment: Hand-grip Dynamometer
Stopwatch with sweep hand

Adjust dynamometer handle to fit grip and hand of subject. With first the right hand and then the left hand, the subject squeezes the grip until the dial reads 20 kg, and then the timing begins. When the subject is no longer able to hold the needle at 20 kg, the timing is stopped. Grip time, to the nearest second is recorded.

Flexed Arm Hang.

Equipment: Stop watch with sweep hand

Protocol: Adjust the bar to the subject's height. Have the subject grasp the bar with a reverse grip, hands shoulder width apart. When the subject becomes airborne with the body held such that the bar is at eye level, timing starts. When the subject can no longer hold him/herself at eye level, timing stops. Record hang time to the nearest second.

ILM Testing.

Purpose: to determine the maximum weight that can be lifted to a height of six feet and five feet.

Lifting Instructions:

For this test, the feet are positioned at a comfortable distance from the handles, about shoulder width apart. The handles are grasped palms down. To start, have the arms straight, back straight, knees bent, and neck hyper-extended (bulled). Begin by first extending knees and hips, and then by using the upper body to complete the lift. The weights must be lifted in one continuous motion to a primary height of six feet thereby clearing the secondary height of five feet during that lift. Upon completion of each lift, the subject will be allowed a rest period of no more than 30 seconds. A 5 second warning will be given before the next trial. If, during the lift, the weights come to a complete stop on the upward phase, the trial will not be allowed. If this lift was at or above the five foot mark, continue lifting heavier weights to the five foot marker. The rest period between the six and five foot lifts will be extended to a maximum of sixty seconds to ensure adequate recovery time for the next series of lifts. Thereafter, the rest periods will return to 30 seconds. The test will end when the subject fails to lift to the five foot marker. The final scores for both tests will be recorded on the data sheets.

Protocols:

Six Foot Lift - After an adequate warm-up, the subject will be allowed three trial lifts at different weights in order to practice the lifting technique. The starting weight will be determined using a chart that considers mass and gender of subjects. The three trial lifts will be performed at a weight less than or equal to the starting mass.

To begin the test, the subject will face the ILM and await instructions to begin lifting. Upon hearing the command "begin lifting", the subject will lift the weight to the six foot marker in one continuous motion, then lower it to the initial position. If the lift is successful (i.e., velocity not = 0) THEN:

i) for each successive lift the weight will be increased in five pound increments for women and ten pound increments for men;
ii) Have the subject rest for a maximum of 30 s. in preparation fot the next lift. He/she will be informed of the following at the 25 second mark: "you have 5 seconds to begin lifting".

If the lift was a failure but the height reached was greater than five feet THEN:

i) the subject may rest for a maximum fo 60 seconds in preparation for the five foot lift (see protocol for five foot lift);
ii) the score of the previous successful lift is recorded as the maximum six foot lift.

Otherwise, if the height reached was less than five feet, the test is over, and the five foot score equals the six foot score.

Five Foot Lift - This is the secondary height for the ILM test and as such is a continuation of the six foot lift protocol. For each successive lift, the weight will increase according to the six foot lift criterion. The subject lifts until the weight cannot be raised to the five foot marker. The test is over and the previous lift is recorded as the five foot lift score.

Cautions:

- keep the back as straight as possible and the neck bulled
- during the initial phase of the lift, do not jerk the weight upward.
- leaning backward or arching forward are not acceptable lifting techniques.
- the subject may stop at any time if he/she feels unable to lift the next weight.

<u>Blood Lactate Determination</u>.

Venous blood samples were taken 3-5 minutes after completion of the leg ergometer test (the subject being instructed to go to the appropriate station after the Wingate test). Lying quietiy supine, a 2-3 ml sample was withdrawn from the anticubital vein, using 18-guage needle and plactic barrell, and heparinized vaccutainer.

APPENDIX D

Results and Interpretations of Preliminary Study

APPENDIX D.

Results and Interpretations of Preliminary Study

1. Kingston Pilot Study

Participants were 12 males (aged 19-33) and 7 females (aged 19-28) from CFB Kingston.

Military Tasks performed included a run and shoot, sand bag lift and carry, entrenchment emplacement, and an overland evacuation task; EXPRES test results were obtained for all participants, the latter being conducted by DPERA personnel prior to the pilot study. The military tasks were performed in accordance with the outline provided by DPERA at CFB Kingston. Final times and heart rates were recorded for each task.

Results

Run and Shoot.

All of the 11 men and 7 women that performed the task were able to complete it within the pass criterion limit of 25 seconds. Mean times were 18.1 ± 1.0 seconds and 21.2 ± 1.2 seconds for men and women, respectively. These completion times for men and women differed significantly ($p<.001$). Heart rates for men (M=172 bpm) and women (M=167 bpm) were relatively high and did not differ significantly for the two groups. Correlational analyses with EXPRES (raw score) variables indicated a fairly strong and significant relationship between time to complete the task and: a) predicted maximal VO2 ($r=-0.70$); and combined maximum grip strength ($r=-0.70$).

Sand Bag Lift and Carry.

Six of the seven women completed the task in the required 10 minutes (Mean time = 7.4 ± 1.7 minutes), the task was completed by all of the men in the required time (Mean time = 5.3 ± 0.2 minutes), and these times to completion differed significantly ($p<.02$). Heart rates for men (M = 174 ± 15 bpm) and women (M = 174 ± 15 bpm) were also relatively high and did not represent a signficant difference between the two groups. Correlational analyses with EXPRES variables indicated a significant but moderate relationship between time to complete the task and: a) maximum combined grip strength ($r=-0.61$); b) predicted maximal oxygen comsumption ($r=-0.64$); c) pushups ($r=-0.54$); and d) situps ($r=-0.54$).

Low High Crawl.

All of the women and 4 of the men were unable to complete the task within the criterion time of 90 seconds. The mean completion times for men and women respectively were 93.1 ± 33.1 s. and 164.0 ± 68.0 s.; these times differed significantly ($p<.01$). Heart rate data for the two groups indicated that this task was very demanding. (Mean Heart rates were 189 ± 14 and 186 ± 15 bpm for men and women respectively.)

Entrenchment Dig

The criterion time for this task of 45 minutes was met by 100% of the men and 33% (n=2) of the women. Mean completion times for men and women were 29.2 ± 10.2 minutes and 53.7 ±21.1 21.1 minutes, respectively, with the women being significantly slower ($p<.03$) as a group than men. Mean heart rates for men and women were 150 ± 15 bpm and 141 ± 9 bpm, respectively. Correlational analyses between task completion time and EXPRES variables evidenced results similar to those obtained for the sand bag carry. Significant but weak-to-moderate coefficients were obtained for the correlation between total time and: a) combined grip strength (r=-0.70) b) predicted maximal VO_2 (r=-0.64); c) pushups (r=-0.57); and d) situps (r=-0.59).

Land Stretcher Carry.

Two of the 6 women and 6 of 7 men completed the task within the allotted 20 minutes. The mean completion time, in minutes, for women was 23.7 ± 59 and for men, 14.4 ± 2.9 minutes. This difference was significant ($p<.01$), with a fairly weak but significant correlation being obtained between total completion time and predicted maximal VO_2 for both groups of subjects.

Comparisons Between Tasks:

The coefficients representing correlations between the task variables are given in Table 1. Relatively high and significant intercorrelations were observed between: a) sand bag lift-and-carry and entrenchment dig; sand bag lift-and-carry and low-high crawl; and b) entrenchment dig and low-high crawl; entrenchment dig and run-and-shoot. However, significant correlations were not observed between total time for the evacuation task and other task completion times.

Significant relationships were noted between the time to complete the run and shoot task and both subjects' aerobic capacity and their combined grip score for reasons that are not entirely clear. For example, run and shoot was not a physiologically demanding task, as judged by subjects' heart rate responses (which were below

TABLE APPD.1. Significant Inter-task Correlation Coefficients.

	Run/Shoot Shoot	Bag Lift & Carry	Low High Crawl	Entrenchment Dig	Land Carry Task
Run & Shoot	--	.66	.71	.83	NS
Sand Bag Lift & Carry	.66	--	.86	.88	NS
Low High Crawl	.71	.86	--	.86	NS
Entrenchment Dig	.83	.88	.86	--	NS
Land Carry Task	NS	NS	NS	NS	--

maximim) upon completion of the task. Further, strength did not appear to be an interacting factor as all subjects passed. Whatever the reasons, it was judged that run and shoot would be removed from the list of tasks to be included in the main study in July.

On the other hand, a number of EXPRES items were found to be related to subjects' performance on both the entrenchment dig and sand bag carry: predominantly muscular components of grip, pushups and situps and aerobic capacity to some degree. However, the entrenchment dig was judged to be the more difficult of these tasks, as evidenced by both subjects' heart rate responses during the test, and the greater number of failures (i.e., only one female failed to complete the sand bag task in the allotted time). Therefore, since both tasks showed very similar relationships with the EXPRES variables, the sand bag carry was removed from the list of tasks to be included in the main study in July.

Finally, the two defined tasks that showed the poorest relationship either to each other, or to the three other tasks (described above) were casualty evacuation and the low-high crawl. Casualty evacuation proved to be a relatively difficult task and with mean completion times being 14 and 24 minutes respectively for men and women, it was surprising that the task was not related to subject's aerobic capacity to a greater extent. Conversely, low-high crawl proved to be a short-term, very intense task (as judged by subjects' post-task heart rates) but again, it was surprising that this task was not more highly related to EXPRES strength and power items. Therefore, it was decided to retain these latter tasks (i.e., casualty evacuation and low-high crawl) in the list of tasks for the July test session.

2. Halifax

Participants were 7 males (aged 19-23) and 8 females (aged 21-28) from CFB Halifax.

Military Tasks performed included a shipboard evacuation task and a fire-fighting task; EXPRES test results were obtained for all participants, the latter being conducted by DPERA personnel prior to the pilot study. The evacuation task was performed in accordance with the outline provided by DPERA and involved two persons carrying a stretcher, bearing a load of approximately 80 kg, from the lower deck to the one above, up a flight of shipboard stairs, then returning down the stairs. Pairs were matched by sex, and by approximate size.

Since it was apparent that a task involving continuous fire-fighting for a period of 30 minutes was unreasonable, this task was divided into three sub-tasks in an attempt to determine the most difficult aspects of the fire-fighting activity. These were termed "Poopdeck Fire", "Endurance Test" and "Drum Fire". For the Poopdeck Fire, individual subjects were required to climb a deck of stairs, handling a charged hose with a low velocity nozzle, hose for one minute, descend and ascend once again while wearing full fire-fighting gear (including Chemox unit). The eight subjects who were inexperienced in fire-fighting performed an endurance test in which they were required to hose with the low velocity nozzle until exhaustion. The remainder, personnel with previous fire-fighting experience, were required to extinguish an actual drum fire using established techniques; these subjects were paired (i.e., 3 pairs performed actual fire-fighting) according to sex, with one person using the high velocity hose, and the other the low velocity hose. Subjects were required to advance towards the large drum fire and extinguish it. Two men performed both the Drum Fire and Endurance tests. Heart rates and completion times were recorded for all three sub-tasks.

Results

Sea Stretcher Carry

One of the three female teams was able to perform the evacuation task within the allotted time limit of 10 minutes (Mean time = 11.37 ± 2.2 min.). The 5 male teams passed (M=2.9 ± 0.3 min.). Heart rates for females (M = 195 ± 15) were significantly ($p<.02$) higher than that for males (M = 175 ± 7 bpm). Correlational analyses with EXPRES variables indicated a strong and significant relationship between time to complete the evacuation task and: a) maximum combined grip strength ($r=-0.9$); and b) predicted maximal $VO2$ ($r=-0.8$); that is, with greater grip strength and aerobic capacity, subjects took progressively less time to complete this task.

Fire-Fighting

Time to extinguish the poopdeck fire did not differ significantly between males and females with the mean overall time being 2.2 min. However subjects' heart rate response did vary ($p<.04$) between the males and females ($M=168 \pm 11$ bpm and $M=181 \pm 9$ bpm respectively).

Endurance test results indicated that males were able to hose significantly longer than women (M=5.1 min. and M=2.0 min. respectively; $t=3.2$, $p<.02$). However, the maximum hosing time was 6.9 min. (well below the originally stated time limit of 30 minutes) and in this instance subjects' heart rates were not significantly different between the two groups with their mean overall heart rate being 151 bpm.

Only one pair of females and two pairs of males were experienced enough to perform the drum fire test (thus the two groups could not be compared statistically). The overall mean time and heart rate for this test was 1.6 min. and 163 bpm, respectively.

A weak correlation was observed between poopdeck fire time and right and left hand maximum grip strength ($r=-0.5$) and predicted VO2 max. ($r=-0.3$).

A strong relationship between the combined grip strength and endurance test time ($r=0.9$) and a weaker relationship with predicted maximal VO2 ($r=0.5$) were observed.

Drum Fire time was strongly related (negatively) to grip strength ($r=-0.8$) and predicted maximal VO_2 ($r=-0.7$).

Conclusions

These correlational analyses suggest that the successful performance of the evacuation task is a function of upper body strength as indicated by maximum grip strength, and also aerobic capacity to some extent. The task, however, was more difficult for the women in the sample than the men as evidenced by total time, number of failures and by the heart rate data. There is some suggestion that the task places different demands on the two sexes, being an upper body task for men, and a total body task for women.

The fire-fighting activity appears to be comprised of two components - forearm strength for hose handling, and aerobic capacity necessitated by two extreme factors: 1) stair climbing especially, while wearing Chemox breathing apparatus; and 2) physiological response to the increased stress introduced by facing a fire.

The average fire could be extinguished in much less time than the person can endure of continuous hosing; however, an individual may be able to fight fires much longer when this involves repetitions of the sequence of advancing toward, extinguishing, then retreating from a fire.

The heart rate data may be a better measure than time for the fire-fighting activity since personal safety is of prime importance. Two persons who completed both the endurance and drum fire tests had higher heart rates for the drum fire than the endurance task even though the latter was longer in duration. The stair climb in itself also seemed to increase the HR. Thus, the components of 'difficulty' of this task appear to be: the stair climb and facing a fire (while wearing Chemox) and not the hosing per se, at least within the length of time required to extinguish the typical drum fire.

APPENDIX E

1985 M.P.F.S. Raw Data

The raw data is recorded in the following order :

1. Kingston Subjects - EXPRES Data
   Laboratory Tests
   Performance Scores
2. Halifax Subjects - EXPRES Data
   Laboratory Tests
   Performance Scores
3. I.L.M. Data - Kingston & Halifax

Kingston EXPRES Data

SIN & Group	Age	Sex	Weight (kg)	Height (cm)	VO2 max. (ml/kg/min)	%ile VO2 max.	Combined Hand Grip Strength (kg)	%ile Grip	Push-Ups	%ile Push-Ups	Sit-Ups	%ile Sit-ups	Chin-ups
323 A	26	M	73.5	175.0	59.9	97	110	83	60	100	54	97	12
326 A	48	M	92.0	184.0	50.5	100	121	97	12	30	29	73	1
331 A	23	M	79.1	171.0	55.1	92	127	97	28	65	56	97	14
363 A	22	F	59.0	167.0	39.2	90	66	89	50	100	52	100	4
473 A	22	M	73.0	175.0	59.3	97	97	53	57	100	58	98	8
547 A	28	F	53.0	165.0	39.9	90	59	77	30	90	35	85	1
625 A	23	F	64.0	168.0	38.5	85	86	100	50	100	45	97	3
629 A	21	M	72.5	182.0	47.7	46	116	89	27	63	44	85	9
648 A	22	F	49.0	167.0	43.0	97	57	65	45	100	34	83	0
702 A	41	M	82.5	188.	43.8	97	108	83	34	97	25	55	7
788 A	25	F	60.5	158.0	40.5	95	69	93	50	100	42	96	5
800 A	45	M	83.5	175.0	38.0	55	104	75	21	77	38	97	5
833 A	23	F	55.5	166.0	37.5	74	68	92	31	91	45	97	0
873 A	20	M	75.7	173.0	55.7	93	99	57	30	73	45	86	4
949 A	26	M	61.5	164.0	56.0	94	97	53	46	97	31	30	11
34 B	26	M	71.2	165.0	55.5	93	115	87	40	93	43	83	7
53 B	32	M	84.0	178.0	47.0	87	130	97	40	97	50	98	9
93 B	51	M	74.0	168.0	34.7	97	114	97	40	100	33	95	5
191 B	30	M	99.7	182.0	43.6	65	112	83	27	80	30	75	2
250 B	35	M	78.0	186.0	46.5	85	108	78	23	65	34	89	5
426 B	27	M	70.3	173.0	53.8	87	110	83	35	85	44	85	10
510 B	23	M	66.5	173.0	55.4	93	108	78	26	60	36	55	4
710 B	32	M	69.0	171.5	47.6	90	99	55	40	93	45	86	8
727 B	41	M	81.5	184.0	40.4	80	128	98	51	100	31	80	11
792 B	30	M	72.0	165.0	53.9	99	117	89	40	97	40	90	4
830 B	34	M	83.0	184.0	42.8	50	132	97	23	65	32	63	7
839 B	30	M	82.5	170.0	44.4	73	124	96	35	95	39	87	5
959 B	51	M	83.0	175.0	38.0	87	104	89	17	60	36	97	3
960 B	30	M	81.9	177.0	45.8	80	128	97	37	97	22	17	8
81 C	21	M	72.0	179.0	48.3	52	151	100	40	93	37	60	
126 C	22	M											
284 C	26	M	73.0	180.0	53.7	87	106	75	30	73	43	83	
429 C	23	M	70.0	196.0	49.8	68	102	65	25	55	44	85	
520 C	27	M	81.0	176.5	55.4	93	107	78	26	60	36	55	
606 C	21	M											
633 C	21	M	77.5	167.0	46.3	40	98	55	51	97	34	45	
681 C	22	M	88.4	165.0	45.0	27	100	60	40	93	31	30	
741 C	19	M											
821 C	20	M	75.0	179.0	49.3	60	114	87	54	99	32	35	
822 C	22	M	64.0	170.0	47.4	45	86	25	46	97	57	97	
835 C	22	M	71.0	171.0	58.9	97	134	97	60	100	43	83	
861 C	21	M	82.8	184.0	46.0	35	119	92	34	83	40	70	
882 C	21	M	74.5	179.0	56.1	95	93	43	35	85	33	40	
904 C	21	M	71.0	162.5	49.8	69	96	50	40	93	39	68	
15 O	20	M	59.0	172.0	51.1	75	105	78	45	97	37	60	
202 O	26	M	82.2	176.0	55.2	93	112	85	36	86	35	50	
376 O	24	M	67.5	179.0	58.2	97	95	48	47	97	52	97	
398 O	21	M	86.0	169.0	46.6	40	109	80	27	63	24	11	

Kingston EXPRES Data

SIN & Group	Age	Sex	Weight (kg)	Height (cm)	VO2 max. (ml/kg/min)	%ile VO2 max.	Combined Hand Grip Strength (kg)	%ile Grip	Push-Ups	%ile Push-Ups	Sit-Ups	%ile Sit-ups	Chin-ups
404 O	20	M	73.0	164.0	56.9	96	100	60	35	85	21	5	
517 D	21	M	62.3	170.0	49.5	60	100	60	33	80	44	85	
549 D	24	M	66.0	167.0	48.2	51	122	95	51	98	57	97	
717 D	21	M	68.5	165.5	48.9	56	90	35	36	86	24	11	
732 O	22	M	66.0	166.5	49.4	60	103	68	42	95	34	45	
743 O	24	M	57.0	155.0	61.7	97	73	8	50	97	46	88	
855 O	22	M	90.0	183.0	46.7	40	111	83	30	73	35	50	
878 O	20	M	72.5	178.0	49.9	64	101	63	38	88	43	83	
958 O	26	M	76.2	174.0	47.9	46	136	98	40	93	34	45	
3 E	46	M	84.5	176.0	44.2	97	101	71	37	97	25	55	4
166 E	23	F	83.3	161.0	30.5	20	75	95	31	75	17	15	0
207 E	30	M	70.2	170.0	47.4	90	115	87	60	100	70	100	17
243 E	34	F											
266 E	24	F	55.0	163.0	41.4	96	74	96	60	100	57	100	3
389 E	35	M	62.5	165.0	41.8	45	97	50	28	88	25	30	10
607 E	26	M	68.5	170.0	37.7	55	92	50	35	85	42	80	
625 E	38	M											
639 E	21	F	59.0	168.0	34.5	35	84	100	40	98	37	60	0
688 E	27	M	71.0	177.0	59.7	97	108	79	50	97	54	97	17
721 E	22	F	54.0	155.0	41.9	96	51	43	42	98	40	95	0
798 E	25	M	82.0	182.0	44.0	22	96	50	20	37	34	45	2
841 E	21	F	62.0	168.0	33.9	25	93	100	40	97	30	70	0
929 E	22	M	76.0	178.0	55.9	93	115	87	30	73	32	35	5
962 E	28	M											
38 F	22	F	68.0	163.0	35.3	45	48	30	41	97	50	99	
55 F	32	M	72.5	178.0	47.1	89	108	76	45	98	38	85	7
70 F	21	F	68.0	173.0	39.7	90	53	50	44	100	37	90	0
75 F	24	M	96.5	188.0	40.8	6	132	97	25	55	33	40	
77 F	30	F	69.5	165.0	33.3	55	89	100	32	90	30	90	1
112 F	37	F	55.0	162.0	36.9	86	59	63	30	93	21	55	0
247 F	22	F	65.0	166.0	34.5	35	68	90	42	99	41	95	0
265 F	33	F	65.0	172.0	35.3	80	65	87	37	97	28	86	0
333 F	28	F	91.5	161.0	31.2	7	68	90	24	78	27	55	0
363 F	33	M	67.5	169.0	46.6	86	101	60	50	100	47	97	
390 F	24	M	81.0	174.0	47.8	48	112	85	30	73	40	95	5
411 F	29	F											
580 F	44	M	96.5	184.0	29.0	3	116	90	35	94	38	96	2
893 F	25	M	101.0	186.0	43.4	18	132	97	25	80	25	12	3
901 F	27	F	59.7	163.0	35.8	50	57	65	23	75	22	33	0

SIN & Group	Kingston Laboratory Tests: Anaerobic Ergometers — Fatigue % Arm	Fatigue % Leg	Average Power Arm (W)	Average Power Leg (W)	Aerobic Test Pred. VO2 (l/min)	Flexed Arm Hang (s)	Percent Body Fat	Endurance Grip (min.) Dominant Hand	Non-Dom. Hand	Combined
323 A	61.1	58.3	1794.2	3271.2	4.4	50.0	14.7	2.0	1.5	3.5
326 A	80.0	50.0	1224.0	2973.6	3.2	35.5	19.6	3.3	3.2	6.5
331 A	58.3	69.2	1340.6	3724.8	2.4	65.0	14.7	2.1	1.7	3.8
363 A	71.4	50.0	967.7	2353.2	2.1	52.4	21.5	0.8	0.8	1.6
473 A	66.7	75.0	1495.2	3459.6	3.8	57.5	8.1	2.0	1.6	3.6
547 A	46.7	50.0	893.0	2080.8	2.0	38.2	21.5	0.9	1.3	2.2
625 A	69.2	55.6	907.7	2115.6	2.4	58.0	14.7	1.2	0.8	2.0
629 A	62.5	72.7	1602.0	3146.4	3.0	67.0	10.5	2.1	1.4	3.5
648 A	61.5	54.5	665.5	2073.6	1.6	36.0	19.5	0.7	0.5	1.2
702 A	61.5	50.0	1008.0	3120.0	3.2	46.0	17.7	3.1	2.5	5.6
788 A	60.0	60.0	946.6	2097.6	2.4	18.0	21.5	2.0	1.7	3.7
800 A	66.7	58.3	1440.0	3432.0	3.3	47.4	24.6	1.3	1.3	2.6
833 A	58.3	54.5	686.9	2058.0	1.4	18.0	23.4	0.5	0.0	0.5
873 A	58.8	41.7	1678.1	2822.4	2.9	31.3	19.0	1.7	1.6	3.3
949 A	60.0	55.6	1313.3	1990.8	2.5	41.0	14.7	2.0	1.0	3.0
34 B	62.5	61.5	3439.8	1628.6	3.8	57.4	10.5	2.1	1.7	3.8
53 B	50.0	63.6	3499.2	1680.0	3.0	44.6	20.4	3.0	2.3	5.3
93 B	61.5	36.4	2425.2	1404.0	3.2	47.5	20.8	2.2	2.1	4.3
191 B	56.3	54.5	4070.4	1872.0	2.6	29.1	22.5	2.2	1.7	3.9
250 B	60.0	50.0	2760.0	1681.9	3.0	23.4	20.4	1.1	1.2	2.3
426 B	56.3	63.6	3024.0	1506.7	2.9	68.0	19.0	2.1	2.3	4.3
510 B	58.8	69.2	3417.0	1440.0	3.8	30.3	8.1	1.5	1.0	2.5
710 B	62.5	42.9	3043.8	1512.0	2.7	45.1	14.2	1.9	1.4	3.3
727 B	56.3	55.6	2533.8	1704.0	3.6	42.1	15.0	4.2	2.2	6.4
792 B	66.7	63.6	3201.6	1647.4	2.4	60.1	20.4	2.5	2.4	4.9
830 B	53.3	55.6	2877.6	1704.0	1.9	24.6	20.4	2.6	2.0	4.6
839 B	53.3	63.6	3465.0	1608.0	2.4	51.6	22.5	4.2	3.3	7.5
959 B	50.0	55.6	2607.6	1464.0	2.7	35.1	22.9	2.6	1.7	4.3
960 B	56.2	41.7	3090.0	1734.5	3.2	46.7	17.7	2.8	1.5	4.3
81 C	61.5	63.6	3036.0	1267.2	2.2	44.3	12.9	3.1	3.1	6.2
126 C	53.3	54.5	3244.8	1658.0	2.8	47.7	16.4	2.7	1.3	4.0
284 C	53.8	66.7	3403.8	1209.6	2.8	49.8	12.9	3.2	2.5	5.7
429 C	71.4	90.0	3186.0	1646.9	2.6	59.3	14.7	1.6	0.9	2.5
520 C	62.5	61.5	3742.2	1848.0	3.3	47.3	14.7	3.0	2.5	5.5
606 C	60.0	81.8	3186.0	1465.4	3.8	43.4	14.7	1.2	0.9	2.1
633 C	56.3	58.3	2639.4	1228.8	2.6	51.8	14.7	2.2	1.5	3.7
681 C	62.5	66.7	4032.0	1848.0	2.7	39.5	20.1	1.3	1.7	3.0
741 C	62.5	61.5	3402.0	1486.1	3.2	43.2	10.5	2.4	1.5	3.9
821 C	58.8	75.0	3348.0	1609.9	2.6	43.2	14.7	2.3	1.5	3.8
822 C	83.3	72.7	2721.6	1286.4	2.1	60.8	17.7	2.3	1.8	4.1
835 C	53.3	63.6	3112.2	1482.5	2.1	45.2	19.0	1.5	1.5	3.0
861 C	62.5	58.3	3855.6	1787.5	2.4	55.2	14.7	2.9	2.1	5.0
882 C	78.6	66.7	3384.0	1620.0	3.2	60.3	15.5	2.8	1.8	4.6
904 C	56.2	63.6	2916.0	1461.6	2.4	38.4	17.7	2.1	2.0	4.1
15 D	55.6	64.3	3152.4	1399.6	2.0	63.7	8.1	1.6	0.9	2.5
202 D	56.3	75.0	4056.0	1800.0	2.5	55.8	17.7	2.4	2.5	4.9
376 D	50.0	66.7	3250.8	1341.4	2.3	76.2	8.1	2.6	2.0	4.6
398 D	46.7	63.6	3498.0	1512.0	2.1	40.7	24.8	1.3	1.4	2.7

Kingston Labotatory Tests

SIN & Group	Anaerobic Ergometers Fatigue % Arm	Fatigue % Leg	Average Power Arm (W)	Average Power Leg (W)	Aerobic Test Pred. VO2 (l/min)	Flexed Arm Hang (s)	Percent Body Fat	Endurance Grip (min.) Dominant Hand	Non-Dom. Hand	Combined
404 D	62.5	50.0	3201.6	1644.7	2.6	60.5	16.4	1.6	1.3	2.9
517 D	68.7	61.5	2880.0	1440.9	2.2	65.6	10.5	0.8	0.6	1.4
549 D	52.9	61.5	3704.4	1633.9	2.2	61.0	14.7	2.8	2.4	5.2
717 D	52.9	63.6	2904.0	1397.3	2.4	52.8	12.9	1.5	1.4	2.9
732 D	64.3	70.0	2772.0	1324.8	2.5	66.3	14.7	1.7	1.0	2.7
743 D	73.3	69.2	2890.8	1321.9	2.4	61.8	10.5	1.1	1.0	2.1
855 D	50.0	58.3	3967.2	1320.0	2.1	61.0	16.4	2.2	2.3	4.5
878 D										
958 D	56.3	58.3	3645.6	1584.7	2.5	48.0	16.4	4.1	1.2	5.3
3 E	69.2	60.0	3175.2	1632.0	4.2	36.5	24.6	1.8	1.8	3.6
166 E	50.0	57.1	2268.0	1190.4	2.2	4.6	38.4	1.1	1.2	2.3
207 E	64.7	80.0	2916.0	1713.1	3.2	65.5	16.2	3.0	1.1	4.1
243 E	63.6	85.7	1778.4	584.6	3.0	16.4	28.2	1.1	0.7	1.8
266 E	53.3	63.6	2246.4	894.2	2.1	69.2	21.5	2.0	0.6	2.6
389 E	64.3	40.0	2268.0	1363.2	2.6	53.6	16.2	1.9	1.5	3.4
607 E	53.3	50.0	3326.4	1382.4	2.2	50.9	13.8	1.9	1.3	3.2
625 E	69.2	72.7	3494.6	1320.0	2.6	57.9	16.2	3.3	2.5	5.8
630 E	61.5	60.0	1960.8	849.1	2.0	43.2	19.5	0.3	0.1	0.4
688 E	71.4	75.0	3477.6	1393.9	4.4	54.2	6.3	2.4	2.2	4.6
721 E	69.2	70.0	2019.6	720.0	1.7	19.3	14.1	0.9	0.3	1.2
798 E	53.3	72.7	3488.4	1608.0	2.3	40.0	22.7	1.8	1.2	3.0
841 E	57.1	63.6	2448.0	936.0	2.1	22.2	21.5	0.6	0.2	0.8
929 E	62.5	53.8	3528.0	1700.1	3.3	25.8	16.4	2.5	3.4	5.9
962 E	57.1	54.5	2289.6	1060.8	2.2	64.2		1.8	1.7	3.5
38 F	69.2	54.5	2671.2	983.0	2.5	24.7	31.2	0.3	1.4	1.7
55 F	66.7	63.6	3146.4	1605.1	4.4	55.8	12.2	3.2	3.3	6.5
70 F	45.5	44.4	2164.8	760.3	2.1	18.7	26.5	0.3	0.2	0.5
75 F	69.2	63.2	3752.4	1608.0	2.8	31.9	21.2	4.3	4.3	8.6
77 F	64.3	54.5	2640.0	1061.2	2.3	19.0	26.5	2.2	1.6	3.8
112 F	75.0	62.5	1672.8	504.0	2.1	11.0	19.5	1.0	0.7	1.7
247 F	57.1			967.2	1.8	28.4	27.8	0.6	0.8	1.4
265 F	58.3	50.0	1663.2	875.5	1.7	19.4	28.2	0.5	0.8	1.3
333 F	75.0	71.4	2296.8	846.7	1.9	0.0	36.4	0.5	0.5	1.0
363 F	66.7	66.7	3115.2	1420.8	2.4	59.8	17.7	1.9	1.2	3.1
390 F	62.5	50.0	3369.6	1824.0	3.1	47.9	19.0	3.0	1.1	4.1
411 F	61.5	50.0	1839.6	790.5	1.7	18.2	29.1	1.1	0.9	2.0
580 F	57.1	77.8	3312.0	1584.0	3.8	49.4	23.0	3.3	2.1	5.4
893 F	66.7	50.0	4147.2	1752.0	3.1	21.5	17.7	2.5	2.4	4.9
901 F	60.0	62.5	1915.2	654.2	1.7	1.0	27.8	0.7	0.4	1.1

SIN & Group	Evacuation Task 1st Rest time (min.)	Evacuation Task 1st Rest distance (m)	Evacuation Task Final heartrate (bpm.)	Evacuation Task Total time (min.)	Low-High Crawl Low time (s)	Low-High Crawl High time (s)	Low-High Crawl Total time (s)	Low-High Crawl Final heartrate (bpm)	Entrenchment Dig Total Time (min.)	Blood Sample Lactate Values (mg%) Queen's Ergometer	Blood Sample Lactate Values (mg%) Low-High Crawl
323 A	3.0	350	168	16.8	33	50	83	156	42.5	81.4	56.6
326 A	5.0	400	168	13.9	37	42	79		90.0	102.1	65.5
331 A			168	11.7	30	35	65	174	34.0	108.4	99.6
363 A	2.9	185	168	60.2	60	52	112	174	75.0	79.8	66.4
473 A	4.0	200	156	13.0	39	42	81	156	44.7	64.4	58.0
547 A	0.7	50	162	24.0	85	49	134	162		81.7	78.8
625 A	3.0	190	168	19.8	66	54	120	180	75.0	53.7	
629 A	3.0	267	150	11.4	37	41	78	168		65.3	66.8
648 A	1.0	58	168	26.0	62	49	111	180		58.8	59.0
702 A	4.1	395	174	12.6	34	32	66	198	39.2	80.5	65.7
788 A	1.2	80	162	23.7	70	64	134	156	90.0	71.7	63.2
800 A	8.4	800	168	10.2	53	86	139	180	70.0	76.9	80.7
833 A	1.0	58	162	80.0	78	56	134	192		69.9	60.3
873 A	4.0	240	168	17.8	33	42	75	192	41.0	91.1	75.0
949 A	3.8	365	180	17.1	49	53	102	198	70.0	78.2	67.7
34 B	2.0	180	168	17.2	32	35	67	180	53.5	80.0	83.3
53 B	3.8	400	168	12.7	38	38	76	192	58.0	85.4	74.6
93 B	4.9	400	162	15.6	46	46	92	162	65.0	104.0	74.6
191 B	2.5	200	156	15.4	42	47	89	180	45.4	88.5	64.8
250 B	3.5	360	168	15.0	28	33	61	186	53.0	89.5	78.4
426 B	4.2	280	156	26.8	31	45	76	204	66.0	103.4	74.3
510 B	1.1	80			33	35	68	192	58.8	66.8	92.4
710 B	1.5	120	180	18.8	31	40	71	180	43.2	71.5	59.2
727 B	3.0	280	168	18.9	41	33	74	192	31.0	79.3	70.9
792 B	1.5	100	186	22.2	39	46	85	174	44.2	94.1	72.2
830 B	5.0	600	162	8.6	46	51	97	174	37.0	62.5	78.3
839 B	5.3	500	162	13.0	34	45	79	174	102.0	84.4	61.4
959 B	3.1	280	156	15.8	48	42	90	168	50.0	75.8	95.1
960 B	2.7	240	174	19.8	37	44	81	186	75.6	79.7	67.8
81 C	1.9	200	168	12.8	43	45	88	180	37.7	60.2	69.6
126 C	2.1	160	174	27.1	33	34	67	192	28.8	64.3	75.3
284 C	2.7	290	186	11.0	32	36	68	204	46.0	77.2	72.5
429 C	2.5	220	186	17.7	47	42	89	198	25.5	50.9	70.9
520 C	2.9	260	168	16.0	37	35	72	162	40.2	77.0	71.0
606 C	2.1	200	186	17.4	36	35	71	204	70.0	74.0	71.5
633 C	2.0	210	180	13.5	39	36	75	192	36.7	79.7	68.8
681 C			168	16.2	34	36	70	186	60.0	67.6	82.9
741 C	3.4	400	180	12.8	35	41	76	174	45.4	72.7	68.0
821 C	4.1	430	222	11.2	32	30	62	198	34.0	84.7	77.9
822 C	1.6	170	186	24.[illegible]	33	37	70	198	50.6	77.0	91.9
835 C	1.3	120	162	23.9	38	44	82	186	70.0	89.6	74.2
861 C	3.1	285	180	14.9	36	37	73	204	39.7	72.7	69.3
882 C	1.5	240	180	14.8	32	46	78	198	44.2	68.1	76.6
904 C	2.2	160	174	17.7	32	33	65	192	26.8	59.4	68.8
15 D	3.5	380		13.5	30	37	67	192	46.6	66.2	83.9
202 D	2.5	250	174	12.0	34	31	65	192	35.8	84.1	73.2
376 D			174	9.0	33	38	71	180	54.5	69.8	64.6
398 D	2.2	140	168	19.4	60	47	107	198	80.0		62.7

SIN & Group	Evacuation Task time (min.)	1st Rest distance (m)	Final heartrate (bpm.)	Total time (min.)	Low-High Crawl Low time (s)	High time (s)	Total time (s)	Final heartrate (bpm)	Entrenchment Dig Total Time (min.)	Blood Sample Lactate Values (mg%) Queen's Ergometer	Low-High Crawl
404 D	1.6	155	174	14.7	27	33	60	192	80.0	71.5	82.4
517 D	2.1	200	174	27.4	41	46	87	180	51.9	45.6	57.6
549 D	2.6	300	168	14.3	25	32	57	186	52.8	99.8	87.3
717 D	2.3	220	144	26.0	42	48	90	168	62.0	61.8	72.3
732 D	2.6	230	162	16.5	49	51	100	180		68.7	61.2
743 D	1.7	140	168	15.6	30	37	67	180		74.4	81.5
855 D	4.0	400	186	11.2	34	32	66	204	38.3	63.6	78.8
878 D	3.0	300	162	16.9	26	29	55	198	78.0		77.1
958 D	2.6	300	180	15.5	30	32	62	192	90.0	68.3	86.3
3 E	3.1	200	150	17.0	34	34	68	168	49.0	58.1	68.7
166 E	1.0	80	168	45.0	140	81	221	174		58.9	72.4
207 E	4.8	590	168	8.6	32	33	65	198	45.5	55.5	80.5
243 E	1.6	120	168	23.2	118	64	182	162	70.0	40.9	68.2
266 E	2.1	18[illegible]	168	16.6	48	46	94	198	62.0	60.8	75.8
389 E	3.5	320	174	19.4	42	48	90	162	60.0	85.6	78.3
607 E	1.7	140	180	18.3	34	40	74	168	33.4	64.7	75.3
625 E	2.9	410	174	8.0	29	38	67	174	29.3	66.2	72.7
630 E	1.0	100	192	29.3	65	52	117	192		48.0	60.8
688 E	3.2	400	162	10.5	31	32	63	180	42.0	47.5	64.0
721 E	1.2	90		40.0	80	70	150	174	120.0	64.0	65.1
798 E	4.0	440	174	11.9	29	35	64	198	90.0	73.8	93.2
841 E	1.5	130		46.0	49	54	103	198		63.0	81.7
929 E	3.0	260	174	15.4	24	31	55	198	33.5	55.3	73.8
962 E	2.4	220	168	15.8	33	40	73	180	30.4	66.5	71.3
38 F	1.1	105	186	22.2	52	53	105	192	120.0	55.6	61.9
55 F	3.6	280	168	14.8	34	34	68	156	70.0	53.6	67.8
70 F	2.2	115		110.0	64	48	112	192	105.0	56.0	62.2
75 F	6.8	600	174	12.4	35	33	68	186	34.0	59.6	68.3
77 F	1.5	140	198	21.4	52	49	101	198	75.0	63.2	65.7
112 F	2.2	160	168	34.0	130	290	420	162		45.6	47.4
247 F	0.8	70	168	39.0	96	64	160	192	70.0	46.9	56.3
265 F	1.4	100	174	54.0	60	62	122	174	105.0	50.6	49.6
333 F	1.2	100	150	78.0	83	63	146	192	120.0	52.1	59.0
363 F	1.7	160	174	17.3	42	41	83	180	53.0	78.0	88.7
390 F	3.9	300	180	13.3	40	41	81	186	40.0	53.2	73.1
411 F	1.5	140	174	38.0	102	90	192	174		54.4	58.4
580 F	5.0	480	156	13.2	50	50	100	162	50.0	51.3	64.4
893 F	3.3	220	168	14.6	48	52	100	180	48.0	72.2	72.4
901 F	0.9	40	132	72.0	89	61	150	180	120.0	49.1	66.5

SIN & Group	Age	Sex	Weight (kg)	Height (cm)	V02 max (ml/kg/min)	Halifax %ile V02 max	EXPRES Data Combined Hand Grip Strength (kg)	%ile Grip	Push-Ups	%ile Push-ups	Sit-Ups	%ile Sit-ups	Chin-Ups
146 A	24	M	70.0	170.0	44.3	25	67.0	3	25	55	32	35	9
158 A	31	M	60.0	178.0	48.4	95	100.0	58	42	97	40	90	10
159 A	21	M	71.5	176.0	56.5	95	100.0	60	30	73	37	60	12
329 A	25	M	98.0	83.0	51.7	75	96.0	50	25	55	25	14	2
331 A	34	M	95.0	180.0	40.3	30	110.0	80	11	20	24	25	2
340 A	41	M	71.6	172.0	39.3	70	102.0	70	20	70	25	55	5
436 A	36	M	78.9	185.0	45.9	80			13	25	18	10	2
495 A	21	M	78.5	185.5	52.3	80	102.0	65	33	80	26	15	6
500 A	32	M	80.0	170.0	40.2	30	148.0	100	30	86	24	25	5
520 A	35	M	68.7	163.0	40.4	30	92.0	37	28	83	21	15	2
608 A	21	M	62.6	164.0	49.0	60	95.0	98			49	95	
809 A	32	M	80.0	174.5	40.0	30	88.0	26	10	18	27	40	4
812 A	22	M	62.4	176.0	57.9	95	91.0	37	54	99	52	97	17
873 A	27	M	64.0	166.0	41.0	10	80.0	15	25	55	21	5	8
117 B	46	M	83.0	181.0	38.3	60	137.0	99	24	83	35	90	3
131 B	30	M	84.3	181.0	42.3	50	114.0	86	19	50	25	30	6
137 B	30	M	66.8	180.0	46.5	85	86.0	23	34	93	44	96	12
165 B	23	M	68.8	185.1	46.2		100.0		24		39		12
367 B	23	M	88.0	180.0	51.7	45	106.0	75	40	93	31	30	9
420 B	25	M	92.0	188.0	38.0	2	115.0	87	15	23	30	28	5
653 B	41	M	81.2	175.0	34.0	15	94.0	50	15	45	17	15	3
658 B	22	M	80.3	188.0	52.7	80	115.0	87	45	97	36	55	7
964 B	21	M	82.0	185.0	45.0	25	117.0	90	35	85	41	75	11
968 B	24	M	75.0	179.0	45.5	30	95.0	47	30	73	36	55	5
49 C	36	M	78.0	173.0	37.2	12	96.0	48	25	73	23	20	6
102 C	34	M	70.0	155.5	48.0	95	120.0	94	34	93	40	90	13
383 C	40	M	70.0	169.9	36.5	40	77.0	14	30	96	28	70	2
493 C	24	M	82.0	182.0	53.4	85	125.0	96	28	68	31	30	7
634 C	32	M	63.3	172.0	42.6	55	105.0	70	30	86	20	14	
775 C	23	M	79.6	177.0	45.8	32	109.0	80	30	73	25	14	4
790 C	22	M	78.5	178.5	45.7	32	103.0	67	30	73	37	60	7
893 C	45	M	81.0	184.0	35.4	25	95.0	53	30	97	10	4	2
944 C	30	M	76.6	178.0	45.5	80	124.0	96	35	95	26	35	11
952 C	40	M	74.0	179.0	40.7	84	95.0	53	19	65	26	60	5
99 D	21	F	61.5	155.0	34.7	35	61.0	80	34	96	36	87	1
158 D	22	F	56.0	161.0	38.2	80	65.0	88	50	100	61	100	4
178 D	21	F	58.0	174.0	38.7	85	73.0	96	43	99	40	95	0
244 D	32	F	72.0	154.0	35.6	80	57.0	63	31	93	26	80	0
404 D	28	F	51.8	168.0	43.7	97	56.0	63	33	93	28	60	1
453 D	23	F	58.3	161.0	38.4	83	61.0	80	24	78	19	20	0
489 D	37	F	67.0	169.0	33.9	60	79.0	97	50	100	32	95	0
650 D	26	F	63.7	163.0	40.4	95	61.0	80	40	97	31	75	0
674 D	22	F	60.2	172.7	37.6	75	68.0	91	31	93	41	95	0
786 D	23	F	60.5	167.0	37.6	75	60.0	75	32	95	55	100	1
802 D	28	F	61.3	168.0	35.3	45	84.0	100	44	100	30	70	0
47 Q	23	M											
358 Q	23	M											
414 Q	26	M											
208 Q	28	F	66.0	173.0	38.0		70.0		29		30		

SIN & Group	Anaerobic Ergometers Arm (W)	Anaerobic Ergometers Leg (W)	Halifax Laboratory Tests: Aerobic Erg. Pred. VO2 (l/min.)	Flexed Arm Hang (s)	Percent Body Fat	Endurance Grip left (s)	Endurance Grip right (s)	Dom. Hand	Evacuation Task: time to stairs trial1 (s)	time to stairs trial2 (s)	time to ascend trial1 (s)	time to ascend trial2 (s)
146 A	1403.5	2592.0	2.40	25.3	16.4	43.0	74.0	R	20.0	17.0	49.0	53.0
158 A	1349.8	2599.2	1.75	58.6	12.8	69.0	72.0	L	11.0	9.0	18.0	11.0
159 A	1436.2	2594.4	3.30	60.9	15.0	63.0	84.0	R	16.0	18.0	33.0	57.0
329 A	1848.0	3553.2	2.75	21.4	23.5	98.0	119.0	R	12.0	14.0	27.0	28.0
331 A	1440.0	2781.6	4.20	31.3	25.7	106.0	121.0	R	15.0	19.0	55.0	43.0
340 A	1415.0	2484.0	2.60	50.0	20.0	62.0	103.0	R	27.0	16.0	52.0	66.0
436 A	1520.6	3000.0	2.90	16.6	23.0	125.0	160.0	R	12.0	14.0	27.0	28.0
495 A	1543.7	3180.0	3.85	57.1	16.0	84.0	127.0	R	16.0	18.0	33.0	57.0
500 A	1787.5	3549.6	3.55	41.6	22.0	121.0	132.0	L	12.0	10.0	16.0	17.0
520 A	1298.9	2323.2	2.05	21.0	25.5	91.0	60.0	R	20.0	17.0	49.0	53.0
608 A	1496.9	3264.0	2.20	55.5	14.7	76.0	107.0	R	11.0	9.0	18.0	11.0
809 A	1622.9	2937.6	2.20	10.4	23.5	61.0	40.0	L	15.0	15.0	42.0	33.0
812 A	1495.7	3216.0	3.65	57.3	9.0	128.0	124.0	R	15.0	15.0	42.0	33.0
873 A	1478.9	2361.6	1.70	26.0	18.0	66.0	114.0	R	27.0	16.0	52.0	66.0
117 B	1340.6	2325.6	3.40	48.2	27.0	127.0	151.0	R	12.0	11.0	26.0	47.0
131 B	1752.0	3366.0	3.25	23.9	19.0	128.0	127.0	R	10.0	10.0	21.0	27.0
137 B	1267.2	2580.0	2.70	48.5	15.2	66.0	78.0	R	11.0	11.0	30.0	18.0
165 B	1641.6	3214.8	3.00	52.0		142.0	181.0	R	17.0	9.0	25.0	17.0
367 B	1824.0	3456.0	2.80	40.8	18.0	92.0	130.0	R	15.0	11.0	30.0	19.0
420 B	1392.0	3220.8	2.70	41.2	23.5	107.0	77.0	R	12.0	11.0	26.0	47.0
653 B	1360.8	2481.6	1.80	33.5	27.3	88.0	61.0	L	15.0	19.0	55.0	43.0
658 B	1680.0	3240.0	3.75	48.2	15.0	63.0	97.0	R	15.0	11.0	30.0	19.0
964 B	1680.0	3427.2	2.20	49.4	14.0	126.0	127.0	R	10.0	10.0	21.0	27.0
968 B	1533.6	2995.2	3.25	61.3	16.5	93.0	123.0	R	17.0	9.0	25.0	17.0
49 C	1474.6	2760.0	2.40	43.7	23.2	102.0	124.0	R	13.0	12.0	49.0	22.0
102 C	1441.4	2948.4	1.70	57.5	15.2	104.0	107.0	R	9.0	11.0	16.0	19.0
383 C	1144.8	2143.2	2.35	32.1	22.0	74.0	111.0	R	15.0	15.0	60.0	62.0
493 C	1536.0	3180.0	3.40	58.2	22.5	83.0	97.0	R	10.0	8.0	25.0	23.0
634 C	1160.6	2558.4	2.20	53.4	16.5	71.0	83.0	R	15.0	15.0	60.0	62.0
775 C	1693.4	3427.2	2.20	39.2	22.7	193.0	164.0	R	7.0	8.0	17.0	17.0
790 C	1843.2	3360.0	1.90	43.9	19.0	100.0	120.0	R	7.0	8.0	17.0	17.0
893 C	1344.0	2376.0	1.60	45.6	30.5	137.0	182.0	R	13.0	12.0	49.0	22.0
944 C	1511.5	2998.8	3.50	33.6	18.0	184.0	259.0	R	10.0	8.0	25.0	23.0
952 C	1404.0		3.15	41.0	19.5	40.0	129.0	R				
99 D	777.6	1968.0	1.90	12.9	26.7	14.0	26.0	R	35.0		538.0	
158 D	964.8	2340.0	2.75	49.8	21.5	24.0	33.0	R	32.0		361.0	
178 D	833.3	2086.8	2.20	40.1	24.0	41.0	45.0	R	35.0		538.0	
244 D	816.0	2160.0	2.20	2.0	36.8	39.0	44.0	R	35.0		245.0	
404 D	654.6	1663.2	2.50	40.5	22.8	27.0	16.0	R	35.0		245.0	
453 D	685.4	1909.2	2.35	12.0	31.2	16.0	20.0	R	32.0		361.0	
489 D	829.4	2270.4	1.90	15.6	29.5	22.0	54.0	R	59.0		150.0	
650 D	720.0	2115.6	2.55	20.5	22.0	43.0	77.0	R	38.0		405.0	
674 D	806.4	2220.0	2.55	24.1	27.5	81.0	111.0	R	39.0		203.0	
786 D	849.1	2143.2	2.50	25.8	27.5	18.0	29.0	L	38.0		405.0	
802 D	890.9	2199.6	2.00	28.3	26.7	55.0	53.0	R	59.0		150.0	
47 Q	1626.2	3532.8	3.45	58.0	13.3	88.0	126.0	R	11.0	11.0	30.0	18.0
358 Q	1810.6	3340.8	1.95	48.0	16.8	113.0	124.0	R	9.0	11.0	16.0	19.0
414 Q	1896.0	4406.4	2.75	59.0	12.8	240.0	360.0	R	12.0	10.0	16.0	17.0
208 Q	807.8	1857.6	2.75	11.0	32.3	65.0	48.0	R	39.0		203.0	

SIN & Group	Evacuation Task (cont.) time to descend trial1 (s)	time to descend trial2 (s)	heartrate 1 trial1 (beats/min.)	heartrate 1 trial2 (beats/min.)	final heartrate trial1 (beats/min.)	final heartrate trial2 (beats/min.)	Final Time trial1 (s)	Final Time trial2 (s)	Fire Fighting heartrate (beats/min.)	Blood Sample Lactate Values (mg%) Queen's Ergometer	Blood Sample Lactate Values (mg%) Stretcher Carry
146 A	66.0	49.0	162	162	174	168	187.0	172.0	175	60.2	39.6
158 A	15.0	9.0	174	156	192	204	69.0	73.0		71.1	72.9
159 A	46.0	39.0	138	144	150	132	140.0	160.0		51.7	
329 A	42.0	40.0	150	168	156	156	121.0	140.0	138	78.8	46.3
331 A	40.0	52.0	132	150	114	180	167.0	171.0	150	68.9	57.8
340 A	32.0	43.0	174	174	168	192	179.0	173.0	180	64.5	78.8
436 A	42.0	40.0	144	168	150	180	121.0	140.0	175	55.3	65.5
495 A	46.0	39.0	192	162	156	174	140.0	160.0		72.9	46.8
500 A	27.0	18.0	168	168	162	180	82.0	77.0		80.1	88.1
520 A	66.0	49.0	174	168	144	174	187.0	172.0	175	61.0	66.9
608 A	15.0	9.0	150	186	162	168	69.0	73.0		79.4	79.5
809 A	26.0	38.0	156	168	162	180	135.0	126.0	162	66.5	44.0
812 A	26.0	38.0	132	174	156	156	135.0	126.0		104.1	53.5
873 A	32.0	43.0	168	180	198	162	179.0	173.0	187	68.0	58.2
117 B	37.0	57.0	132	162	156	138	130.0	158.0	138	48.9	51.9
131 B	27.0	19.0	168	156	150	162	96.0	88.0		67.1	54.2
137 B	40.0	16.0	144	168	162	180	114.0	84.0	150	69.0	63.5
165 B	33.0	29.0	180	174	168	180	114.0	99.0	182	78.8	55.4
367 B	39.0	20.0	168	174	180	162	124.0	88.0		77.7	44.2
420 B	37.0	57.0	168	168	168	174	130.0	158.0	162	63.2	54.4
653 B	40.0	52.0	156	144	168	132	167.0	171.0	180	73.2	69.1
658 B	39.0	20.0	150	144	144	162	124.0	88.0	150	76.7	38.9
964 B	27.0	19.0	168	192	186	174	96.0	88.0	175	74.4	42.2
968 B	33.0	29.0	150	156	180	156	114.0	99.0	160	77.2	39.6
49 C	33.0	33.0	150	174	144	150	134.0	107.0	170	60.3	46.7
102 C	22.0	24.0	168	174	150	156	86.0	85.0		78.6	71.9
383 C	88.0	74.0	174	180	182	186	233.0	221.0		60.2	88.7
493 C	27.0	25.0	144	144	156	174	100.0	101.0	166	106.4	83.4
634 C	88.0	74.0	168	162	180	174	233.0	221.0	166	82.3	63.4
775 C	27.0	21.0	174	174	168	174	83.0	85.0	168	90.3	55.0
790 C	27.0	21.0	156	174	180	168	83.0	85.0	175	83.5	45.0
893 C	33.	33.0	162	174	168	186	134.0	107.0	155	82.8	87.4
944 C	27.	25.0	138	138	138	162	100.0	101.0	171	75.2	57.6
952 C									115		
99 O	199.0		186		180		992.0		191	77.4	66.2
158 D	94.0		204		186		647.0		161	85.3	86.2
178 D	199.0		180		174		992.0		177	78.3	66.2
244 D	75.0		168		150		446.0		180	77.5	77.6
404 D	75.0		168		168		446.0		162	59.7	71.3
453 D	94.0		180		192		647.0		147	85.2	64.0
489 O	104.0		198		180		422.0		169	63.3	66.0
650 D	234.0		192		192		708.0		150	80.3	61.4
674 O	55.0		192		168		424.0		165	65.8	60.5
786 O	234.0		174		174		708.0		168		72.5
802 D	104.0		192		180		422.0		187	82.8	80.3
47 Q	40.0	16.0	150	174	174	174	114.0	84.0			
358 Q	22.0	24.0	186	186	198	210	86.0	85.0			
414 Q	27.0	18.0	174	168	162	168	82.0	77.0			
208 Q	55.0		174		174		424.0				

Subject SIN & Group	Weight (kg)	Time to Six Feet	Time at Peak 1 Velocity	Time at Peak 1 Acc/For	Time at Peak 2 Acc/For	Time at Peak 3 Acc/For	Time at Peak 1 Power	Disp at Peak 1 Velocity	Disp at Peak 1 Acc/For	Disp at Peak 2 Acc/For	Disp at Peak 3 Acc/For	Disp at Peak 1 Power
		S.	S.	S.	S.	S.	S.	m	m	m	m	m
Kingston Subjects	MASS	TMAX	T1	T3	T4	T5	t6	d1	d3	d4	d5	d6
323 A	55.34	1.66	0.39	0.05	0.65	1.29	0.29	0.99	0.43	1.47	1.65	0.77
326 A	46.27	1.39	0.41	0.05	0.70	1.05	0.32	1.06	0.42	1.61	1.72	0.86
331 A	68.95	1.33	0.34	0.06	0.56	0.76	0.25	0.91	0.42	1.33	1.44	0.71
363 A	30.39	2.54	0.34	0.06	0.59	0.87	0.26	0.85	0.43	1.22	1.32	0.70
473 A	64.41	1.17	0.37	0.06	0.62	0.83	0.23	0.91	0.43	1.29	1.35	0.65
547 A	25.85	1.32	0.35	0.06	0.61	1.01	0.26	0.95	0.43	1.49	1.64	0.74
625 A	30.39	1.55	0.36	0.04	0.65	0.93	0.29	0.99	0.43	1.51	1.59	0.83
629 A	55.34	1.34	0.39	0.04	0.69	1.06	0.28	0.98	0.42	1.41	1.48	0.77
648 A	23.58	1.80	0.34	0.05	0.58	0.97	0.26	0.88	0.41	1.33	1.51	0.71
702 A	55.34	1.50	0.42	0.06	0.70	1.23	0.34	1.06	0.43	1.59	1.68	0.87
788 A	25.85	2.41	0.33	0.05	0.57	1.07	0.23	0.91	0.42	1.33	1.41	0.69
800 A	41.73	2.11	0.40	0.05	0.66	1.85	0.32	0.97	0.42	1.43	1.76	0.81
833 A	23.58	2.57	0.35	0.05	0.68	0.96	0.25	0.85	0.42	1.34	1.39	0.68
873 A	50.80	2.57	0.41	0.04	0.71	0.92	0.34	0.92	0.43	1.37	1.44	0.82
949 A	41.73	1.19	0.31	0.05	0.50	0.75	0.23	0.95	0.44	1.32	1.47	0.77
034 B	64.41	1.91	0.42	0.06	0.61	0.86	0.34	1.01	0.42	1.39	1.57	0.83
053 B	55.34	1.48	0.36	0.05	0.64	1.26	0.28	1.01	0.43	1.55	1.67	0.82
093 B	50.80	1.53	0.35	0.05	0.65	0.87	0.23	1.00	0.44	1.50	1.57	0.75
191 B	59.87	1.76	0.38	0.05	0.59	1.42	0.33	1.04	0.43	1.45	1.72	0.93
250 B	46.27	1.58	0.38	0.06	0.62	1.54	0.25	1.02	0.43	1.49	1.79	0.72
426 B	46.27	1.28	0.27	0.05	0.52	0.82	0.19	0.93	0.45	1.50	1.61	0.72
510 B	41.73	1.27	0.34	0.05	0.67	1.07	0.26	0.94	0.42	1.56	1.69	0.77
710 B	46.27	2.16	0.34	0.05	0.51	1.79	0.27	0.97	0.44	1.31	1.76	0.81
727 B	59.87	1.42	0.36	0.04	0.58	1.07	0.29	1.02	0.43	1.47	1.70	0.85
792 B	50.80	1.78	0.29	0.05	0.57	1.62	0.21	0.89	0.44	1.40	1.72	0.72
830 B	46.27	0.80	0.37	0.06	0.61	0.80	0.27	1.06	0.43	1.61	1.80	0.81
839 B	46.27	1.50	0.39	0.03	0.63	0.96	0.26	1.00	0.42	1.42	1.56	0.75
959 B	50.80	1.67	0.37	0.05	0.60	0.77	0.22	1.01	0.44	1.41	1.51	0.70
960 B	59.87	1.78	0.40	0.06	0.68	1.45	0.30	1.00	0.42	1.52	1.67	0.78
081 C	46.27	1.06	0.34	0.05	0.59	1.03	0.28	1.00	0.43	1.53	1.79	0.86
126 C	59.87	1.17	0.34	0.04	0.61	0.88	0.08	0.96	0.43	1.38	1.45	0.48
284 C	50.80	1.52	0.36	0.06	0.65	0.86	0.12	0.99	0.45	1.49	1.58	0.53
429 C	55.34	2.15	0.31	0.05	0.54	1.86	0.24	0.96	0.43	1.45	1.76	0.77
520 C	55.34	1.12	0.34	0.04	0.55	0.94	0.25	0.99	0.42	1.44	1.70	0.77
606 C	46.27	1.85	0.40	0.05	0.61	1.85	0.31	0.95	0.42	1.31	1.80	0.78
633 C	41.73	1.08	0.32	0.05	0.59	0.95	0.09	0.98	0.44	1.51	1.74	0.50
681 C	50.80	1.11	0.43	0.06	0.76	1.00	0.31	1.06	0.43	1.65	1.77	0.79
741 C	50.80	0.93	0.34	0.05	0.57	0.84	0.27	1.02	0.43	1.54	1.76	0.84
821 C	46.27	0.78	0.32	0.05	0.57	0.78	0.19	1.03	0.44	1.60	1.80	0.70
835 C	50.80	1.45	0.47	0.08	0.73	0.99	0.39	1.00	0.43	1.47	1.56	0.83
861 C	55.34	1.01	0.34	0.05	0.67	0.88	0.23	1.02	0.44	1.66	1.76	0.75
882 C	46.27	1.32	0.33	0.06	0.65	0.84	0.17	0.95	0.45	1.48	1.51	0.62
904 C	55.34	1.76	0.33	0.05	0.59	1.05	0.24	0.91	0.43	1.33	1.47	0.73
015 D	41.73	1.37	0.35	0.06	0.60	0.90	0.27	0.92	0.44	1.35	1.48	0.76
202 D	46.27	0.91	0.41	0.04	0.66	0.90	0.29	1.11	0.43	1.61	1.80	0.84
376 D	46.27	0.84	0.40	0.06	0.63	0.84	0.32	1.09	0.43	1.61	1.80	0.88
404 D	55.34	1.78	0.32	0.05	0.61	0.87	0.24	0.82	0.43	1.23	1.28	0.69

Subject SIN & Group	Weight (kg) MASS	Time to Six Feet s. TMAX	Time at Peak 1 Velocity s. T1	Time at Peak 1 Acc/For s. T3	Time at Peak 2 Acc/For s. T4	Time at Peak 3 Acc/For s. T5	Time at Peak 1 Power s. t6	Disp at Peak 1 Velocity m d1	Disp at Peak 1 Acc/For m d3	Disp at Peak 2 Acc/For m d4	Disp at Peak 3 Acc/For m d5	Disp at Peak 1 Power m d6
Kingston Subjects												
517 O	50.80	1.16	0.33	0.07	0.55	0.81	0.26	0.93	0.45	1.36	1.49	0.77
549 D	46.27	1.03	0.33	0.09	0.56	1.10	0.25	0.97	0.46	1.49	1.83	0.76
717 D	37.19	1.46	0.32	0.04	0.61	1.11	0.21	0.93	0.43	1.44	1.54	0.69
732 D	46.27	1.58	0.39	0.07	0.65	1.10	0.28	1.02	0.43	1.51	1.60	0.77
743 O	46.27	2.23	0.33	0.06	0.52	0.76	0.24	0.84	0.42	1.15	1.24	0.67
855 O	64.41	1.18	0.37	0.05	0.61	0.99	0.25	1.07	0.43	1.59	1.76	0.77
958 O	50.80	1.37	0.35	0.06	0.69	0.92	0.22	0.91	0.43	1.43	1.48	0.66
003 E	46.27	1.57	0.60	0.06	0.84	1.09	0.45	1.03	0.40	1.35	1.40	0.80
166 E	30.39	1.25	0.30	0.07	0.49	1.52	0.13	0.90	0.47	1.27	1.82	0.56
207 E	55.34	1.37	0.32	0.05	0.65	0.89	0.23	0.90	0.43	1.44	1.51	0.71
243 E	23.58	2.16	0.67	0.04	1.00	1.22	0.57	1.08	0.41	1.46	1.50	0.93
266 E	30.39	2.15	0.31	0.08	0.55	2.21	0.23	0.94	0.47	1.45	1.83	0.75
389 E	28.12	1.52	0.45	0.06	0.83	1.05	0.40	0.84	0.41	1.36	1.48	0.77
607 E	41.73	1.08	0.38	0.08	0.60	1.17	0.27	1.06	0.45	1.55	1.83	0.79
625 E	55.34	1.27	0.35	0.05	0.58	1.11	0.29	1.04	0.44	1.53	1.76	0.89
630 E	23.58	1.82	0.35	0.09	0.55	1.04	0.27	0.92	0.46	1.30	1.52	0.74
688 E	46.27	1.23	0.39	0.05	0.62	0.96	0.34	1.08	0.44	1.55	1.66	0.96
721 E	21.32	1.23	0.33	0.05	0.52	1.04	0.22	0.94	0.43	1.33	1.68	0.70
798 E	46.27	1.29	0.36	0.05	0.74	0.98	0.30	0.85	0.41	1.42	1.47	0.73
841 E	30.39	1.91	0.37	0.05	0.65	0.90	0.27	0.97	0.43	1.43	1.50	0.76
929 E	50.80	1.42	0.47	0.08	0.73	1.02	0.34	1.06	0.44	1.52	1.63	0.80
962 E	23.58	1.62	0.50	0.05	0.71	1.11	0.30	0.93	0.41	1.22	1.52	0.65
038 F	32.66	1.88	0.34	0.07	0.52	1.70	0.24	0.94	0.46	1.29	1.71	0.75
055 F	41.73	1.57	0.58	0.08	0.87	1.11	0.47	1.09	0.42	1.54	1.59	0.88
070 F	21.32	1.01	0.46	0.05	0.64	1.01	0.33	1.08	0.41	1.43	1.80	0.80
075 F	46.27	0.74	0.39	0.06	0.61	0.74	0.25	1.15	0.44	1.66	1.80	0.79
077 F	50.80	1.67	0.36	0.05	0.57	1.58	0.28	0.92	0.41	1.32	1.76	0.75
112 F	19.05	2.57	0.51	0.05	0.85	1.69	0.43	0.92	0.41	1.34	1.59	0.80
247 F	25.85	1.88	0.54	0.07	0.86	1.19	0.40	1.04	0.41	1.49	1.63	0.79
265 F	23.58	2.07	0.46	0.06	0.65	1.09	0.35	0.98	0.41	1.28	1.53	0.78
333 F	30.39	2.57	0.47	0.05	0.68	1.16	0.39	0.83	0.41	1.08	1.31	0.73
363 F	55.34	2.05	0.37	0.05	0.62	0.94	0.31	0.91	0.42	1.31	1.43	0.80
390 F	55.34	1.34	0.39	0.05	0.66	0.88	0.33	0.97	0.43	1.40	1.47	0.85
411 F	25.85	2.57	0.42	0.06	0.64	0.91	0.35	0.87	0.42	1.17	1.31	0.76
580 F	46.27	1.19	0.47	0.06	0.76	0.99	0.33	1.10	0.45	1.60	1.71	0.83
893 F	37.19	1.64	0.91	0.05	1.17	1.36	0.88	1.20	0.40	1.48	1.63	1.17
901 F	21.32	1.73	0.37	0.06	0.65	0.96	0.29	0.92	0.42	1.39	1.46	0.75
Halifax Subjects												
146 A	46.27	1.37	0.42	0.07	0.64	0.91	0.32	0.98	0.43	1.35	1.48	0.79
158 A	46.27	1.88	0.33	0.09	0.55	0.94	0.24	0.87	0.46	1.26	1.43	0.69
159 A	59.87	2.49	0.33	0.09	0.53	0.81	0.23	0.86	0.46	1.21	1.37	0.67
329 A	50.80	0.90	0.40	0.08	0.61	0.84	0.23	1.09	0.46	1.53	1.76	0.71
331 A	50.80	0.93	0.45	0.07	0.63	1.02	0.34	1.16	0.44	1.55	1.82	0.90
340 A	41.73	1.85	0.42	0.07	0.77	0.99	0.32	0.92	0.43	1.42	1.46	0.75

Subject SIN & Group Halifax Subjects	Weight (kg) MASS	Time to Six Feet S. TMAX	Time at Peak 1 Velocity S. T1	Time at Peak 1 Acc/For S. T3	Time at Peak 2 Acc/For S. T4	Time at Peak 3 Acc/For S. T5	Time at Peak 1 Power S. t6	Disp at Peak 1 Velocity m d1	Disp at Peak 1 Acc/For m d3	Disp at Peak 2 Acc/For m d4	Disp at Peak 3 Acc/For m d5	Disp at Peak 1 Power m d6
495 A	46.27	1.26	0.51	0.06	0.83	1.05	0.38	1.15	0.43	1.65	1.73	0.90
500 A	50.80	1.11	0.39	0.08	0.62	1.10	0.29	1.07	0.46	1.55	1.80	0.82
520 A	41.73	1.78	0.35	0.06	0.56	0.76	0.27	0.95	0.44	1.31	1.45	0.78
608 A	46.27	1.68	0.31	0.06	0.56	0.84	0.21	0.90	0.45	1.35	1.46	0.69
809 A	46.27	0.79	0.32	0.07	0.53	1.19	0.14	1.04	0.47	1.55	1.91	0.59
812 A	50.80	1.38	0.51	0.07	0.72	0.93	0.33	1.08	0.43	1.41	1.55	0.76
873 A	41.73	1.04	0.46	0.08	0.62	1.10	0.35	1.09	0.44	1.41	1.85	0.86
117 B	37.19	1.66	0.80	0.66	1.05	1.32	0.72	1.06	0.80	1.47	1.54	0.90
131 B	59.87	0.00	0.39	0.09	0.71	1.02	0.29	0.87	0.45	1.30	1.36	0.71
137 B	41.73	1.80	0.47	0.09	0.73	0.93	0.36	1.04	0.43	1.47	1.58	0.83
165 B	55.34	1.66	0.39	0.09	0.63	0.90	0.31	0.93	0.45	1.32	1.37	0.77
367 B	64.41	1.44	0.42	0.08	0.67	0.91	0.27	1.07	0.45	1.51	1.58	0.76
420 B	46.27	1.58	0.54	0.08	0.78	1.33	0.44	1.12	0.42	1.57	1.74	0.89
653 B	32.66	1.54	0.47	0.07	0.71	1.21	0.38	0.86	0.41	1.17	1.33	0.72
658 B	50.80	1.59	0.36	0.07	0.66	0.88	0.21	1.00	0.45	1.54	1.61	0.67
964 B	64.41	1.23	0.39	0.06	0.68	0.93	0.31	1.00	0.44	1.42	1.47	0.84
968 B	41.73	1.54	0.41	0.08	0.65	1.49	0.31	0.99	0.43	1.43	1.79	0.78
049 C	50.80	1.79	0.42	0.09	0.60	0.85	0.33	0.97	0.44	1.31	1.48	0.78
102 C	50.80	1.56	0.34	0.07	0.63	0.91	0.25	0.94	0.45	1.47	1.60	0.74
383 C	41.73	1.24	0.38	0.08	0.62	0.83	0.29	0.95	0.44	1.40	1.55	0.76
493 C	55.34	1.19	0.43	0.08	0.71	0.91	0.34	0.96	0.43	1.44	1.57	0.79
634 C	37.19	1.25	0.34	0.07	0.60	0.89	0.25	0.93	0.44	1.42	1.61	0.73
775 C	50.80	1.25	0.38	0.08	0.59	0.94	0.30	0.94	0.45	1.31	1.44	0.77
790 C	41.73	0.84	0.34	0.07	0.54	1.07	0.14	1.04	0.46	1.49	1.96	0.58
893 C	41.73	1.78	0.40	0.06	0.68	0.94	0.30	0.97	0.42	1.41	1.48	0.77
944 C	55.34	1.54	0.36	0.07	0.59	0.84	0.25	1.01	0.45	1.45	1.60	0.76
952 C	41.73	1.20	0.46	0.08	0.69	1.03	0.37	1.08	0.43	1.52	1.72	0.89
099 D	19.05	1.06	0.34	0.07	0.59	0.92	0.25	0.93	0.44	1.41	1.71	0.74
158 D	30.39	1.85	0.37	0.07	0.57	0.89	0.29	0.90	0.43	1.24	1.45	0.74
178 D	28.12	1.60	0.32	0.07	0.61	1.77	0.15	0.92	0.45	1.45	1.87	0.57
244 D	25.85	2.35	0.28	0.06	0.58	0.98	0.12	0.82	0.45	1.26	1.32	0.53
404 D	21.32	2.21	0.44	0.08	0.68	0.91	0.36	0.96	0.43	1.35	1.47	0.80
453 D	25.85	2.39	0.44	0.07	0.70	1.00	0.35	0.97	0.43	1.35	1.42	0.81
489 D	25.85	2.30	0.68	0.07	0.95	1.24	0.62	0.99	0.40	1.26	1.35	0.91
650 D	25.85	1.83	0.29	0.07	0.45	1.52	0.19	0.80	0.44	1.08	1.64	0.61
674 D	19.05	2.25	0.39	0.09	0.67	2.03	0.29	0.92	0.44	1.40	1.75	0.72
786 D	23.58	1.89	0.44	0.07	0.68	0.92	0.36	0.94	0.42	1.31	1.42	0.79
802 D	25.85	1.44	0.38	0.07	0.63	1.47	0.30	0.97	0.43	1.43	1.82	0.79
047 Q	59.87	1.38	0.38	0.08	0.61	0.91	0.28	1.01	0.46	1.44	1.56	0.79
208 Q	23.58	1.81	0.40	0.07	0.59	0.89	0.31	0.94	0.42	1.27	1.42	0.75
358 Q	64.41	1.58	0.35	0.06	0.50	0.70	0.27	0.90	0.43	1.17	1.34	0.74
414 Q	84.82	1.17	0.38	0.07	0.62	0.86	0.30	0.97	0.45	1.38	1.47	0.80

Subject SIN & Group Kingston Subjects	Speed at Peak 1 Velocity m/s s1	Speed at Min 1 Velocity m/s s2	Speed at Peak 1 Acc/For m/s s3	Speed at Peak 2 Acc/For m/s s4	Speed at Peak 3 Acc/For m/s s5	Speed at Peak 1 Power m/s s6	Acc at Peak 1 Velocity m/s^2 a1	Acc at Peak 1 Acc/For m/s^2 a3	Acc at Peak 2 Acc/For m/s^2 a4	Acc at Peak 3 Acc/For m/s^2 a5	Acc at Peak 1 Power m/s^2 a6	Force at Peak 1 Velocity N f1
323 A	2.07	0.01	0.87	1.27	0.19	1.92	-0.23	8.17	-7.30	1.60	3.23	530.16
326 A	2.29	0.11	0.82	1.06	0.16	2.14	-0.01	9.35	-7.74	0.85	2.77	453.31
331 A	2.29	0.37	0.83	1.13	0.47	2.08	-0.24	9.31	-8.87	2.29	4.90	660.14
363 A	1.86	-0.05	0.84	0.83	0.47	1.75	0.03	8.10	-6.23	4.50	2.67	299.18
473 A	1.97	0.08	0.79	0.64	0.85	1.69	-0.16	8.06	-8.78	11.45	3.98	621.66
547 A	2.49	0.18	0.83	1.21	0.36	2.21	0.08	8.79	-9.35	1.69	5.75	255.70
625 A	2.36	0.16	0.82	0.85	0.28	2.20	0.06	8.21	-9.37	1.24	4.25	299.85
629 A	1.95	-0.08	0.87	0.59	0.75	1.81	-0.36	8.35	-6.95	6.17	2.40	523.22
648 A	2.26	0.28	0.69	1.17	0.37	2.01	0.29	8.19	-7.54	0.93	5.47	238.21
702 A	2.44	-0.01	0.78	0.95	0.25	2.23	0.13	7.52	-9.94	2.42	4.29	550.06
788 A	2.22	-0.01	0.83	1.03	0.22	1.99	-0.27	9.92	-9.32	2.31	4.60	246.55
800 A	2.09	0.08	0.73	1.23	0.14	1.95	0.21	7.84	-5.31	0.59	3.11	417.93
833 A	1.91	0.03	0.69	0.61	0.26	1.74	-0.19	8.05	-7.41	2.44	3.27	248.56
873 A	1.82	0.21	0.69	0.67	0.55	1.75	-0.19	7.07	-8.13	4.87	2.29	488.54
949 A	2.32	0.41	1.11	1.22	0.66	2.18	-0.40	11.88	-10.35	3.58	3.36	392.83
034 B	2.29	0.14	0.71	1.40	0.44	2.11	-0.16	7.59	-8.61	-0.40	3.80	621.41
053 B	2.46	.00	0.93	0.99	0.44	2.27	-0.31	10.25	-9.04	2.76	4.24	525.75
093 B	2.13	0.17	1.10	0.85	0.24	2.00	-0.01	11.21	-8.04	1.36	2.36	498.03
191 B	2.30	0.18	0.93	1.27	0.21	2.23	0.25	10.05	-8.73	0.62	1.91	602.17
250 B	2.34	0.12	0.91	1.27	0.26	2.06	-0.30	9.12	-7.70	1.09	4.55	439.86
426 B	2.78	0.01	1.24	1.38	0.15	2.50	-0.60	12.67	-9.83	2.42	7.19	426.08
510 B	2.21	0.11	0.90	0.94	0.49	2.08	0.11	9.97	-9.17	1.96	3.21	414.15
710 B	2.36	-0.02	1.00	1.52	0.01	2.18	-0.42	9.34	-7.51	0.96	4.68	434.49
727 B	2.46	0.23	0.87	1.35	0.30	2.30	-0.04	9.80	-6.83	0.88	3.95	585.13
792 B	2.26	0.16	1.10	1.03	0.47	2.11	-0.24	11.40	-7.72	1.17	3.73	486.29
830 B	2.63	0.61	0.95	1.60	0.61	2.39	-0.15	10.59	-7.65	-3.39	4.74	447.19
839 B	2.04	0.26	0.83	1.12	0.33	1.79	-0.01	8.50	-7.39	0.84	3.87	453.58
959 B	2.10	0.20	1.03	1.08	0.48	1.90	-0.17	10.57	-7.84	1.24	3.02	489.95
960 B	2.34	-0.01	0.78	1.05	0.27	2.11	-0.22	7.66	-7.55	1.83	4.47	573.92
081 C	2.42	0.40	1.03	1.40	0.47	2.31	0.30	12.01	-9.27	1.00	2.87	467.91
126 C	2.03	0.02	1.01	0.67	0.75	1.45	-0.21	11.22	-8.31	7.86	8.20	574.71
284 C	2.14	0.03	1.05	0.92	0.39	1.54	-0.01	8.66	-7.95	2.22	6.13	498.06
429 C	2.64	0.02	1.00	1.31	0.06	2.41	0.00	10.89	-9.68	1.22	5.69	543.07
520 C	2.51	0.49	0.90	1.43	0.55	2.26	0.03	9.49	-8.15	0.97	5.10	544.73
606 C	1.94	0.19	0.69	1.37	0.26	1.83	-0.10	8.28	-4.27	0.53	2.73	449.49
633 C	2.37	0.41	1.09	1.29	0.44	1.53	0.10	11.35	-6.12	0.90	9.03	413.66
681 C	2.26	0.25	0.74	1.01	0.29	2.07	-0.18	7.84	-6.64	-0.35	3.60	489.11
741 C	2.63	0.44	1.00	1.52	0.54	2.47	-0.06	10.14	-8.50	-0.95	4.43	495.33
821 C	2.58	0.51	1.18	1.67	0.51	2.29	-0.17	13.13	-7.87	-2.80	4.97	446.07
835 C	2.21	0.18	0.60	1.01	0.35	2.03	0.08	5.05	-8.16	2.44	4.03	502.56
861 C	2.58	0.26	1.00	0.92	0.35	2.27	-0.39	10.09	-8.90	0.01	5.60	521.14
882 C	2.24	.00	1.06	0.66	0.22	1.86	-0.42	9.49	-9.34	4.40	5.00	434.56
904 C	2.06	-0.03	0.98	0.77	0.81	1.90	-0.10	10.13	-9.91	3.44	2.88	537.56
015 D	2.07	-0.03	0.93	1.05	0.49	1.92	.00	6.81	-6.38	4.55	3.26	409.34
202 D	2.39	0.56	0.90	1.32	0.58	2.13	0.17	9.06	-6.98	0.32	3.61	461.84
376 D	2.62	0.52	0.86	1.59	0.52	2.42	0.19	9.34	-7.90	-2.31	4.34	462.38
404 D	1.77	-0.02	0.80	0.64	0.62	1.65	0.08	8.34	-8.44	7.98	2.30	547.52

Subject SIN & Group	Speed at Peak 1 Velocity m/s s1	Speed at Min 1 Velocity m/s s2	Speed at Peak 1 Acc/For m/s s3	Speed at Peak 2 Acc/For m/s s4	Speed at Peak 3 Acc/For m/s s5	Speed at Peak 1 Power m/s s6	Acc at Peak 1 Velocity m/s^2 a1	Acc at Peak 1 Acc/For m/s^2 a3	Acc at Peak 2 Acc/For m/s^2 a4	Acc at Peak 3 Acc/For m/s^2 a5	Acc at Peak 1 Power m/s^2 a6	Force at Peak 1 Velocity N f1
Kingston Subjects												
517 D	2.32	0.09	1.05	1.17	0.76	2.17	0.23	8.97	-9.01	7.32	3.54	509.87
549 D	2.69	0.02	1.18	1.56	0.43	2.44	0.23	10.33	-7.38	0.69	5.31	464.43
717 D	2.23	0.03	0.92	0.91	0.40	1.93	-0.19	9.10	-9.02	3.33	4.69	357.75
732 D	2.37	.00	0.89	0.99	0.23	2.15	-0.08	9.15	-9.40	1.56	3.85	450.14
743 D	1.95	0.22	0.82	0.95	0.48	1.79	-0.33	8.84	-9.08	4.03	3.35	438.60
855 D	2.60	0.22	0.94	1.38	0.23	2.30	-0.45	10.20	-9.80	0.12	5.03	603.15
958 D	2.03	0.03	0.84	0.63	0.34	1.80	-0.05	9.00	-8.70	3.87	3.68	495.86
003 E	1.64	-0.01	0.40	0.68	0.35	1.49	-0.16	3.88	-7.50	4.90	1.99	446.34
166 E	2.18	-0.03	1.18	1.52	-0.01	1.70	-0.05	9.41	-6.00	0.29	6.70	296.62
207 E	2.20	0.20	0.89	0.72	0.39	2.00	0.07	9.90	-7.92	2.52	3.84	546.57
243 E	1.59	0.08	0.46	0.46	0.30	1.48	0.04	4.37	-4.98	3.48	2.18	232.18
266 E	2.51	-0.03	1.26	1.38	0.47	2.29	0.22	9.99	-7.61	0.91	4.30	304.96
389 E	1.53	0.44	0.46	0.85	0.57	1.47	0.22	4.95	-5.02	2.45	1.77	282.04
607 E	2.54	0.24	1.10	1.52	0.36	2.29	-0.03	9.34	-8.14	1.19	3.93	408.13
625 E	2.55	0.25	1.05	1.36	0.27	2.42	0.06	10.43	-7.78	0.48	3.61	546.47
630 E	2.25	0.18	0.98	1.35	0.24	2.05	-0.03	7.97	-6.05	0.78	3.97	230.70
688 E	2.51	0.08	0.94	1.21	0.27	2.40	-0.01	9.89	-9.27	2.26	3.58	453.58
721 E	2.29	0.46	0.92	1.55	0.56	2.05	-0.06	10.19	-7.59	1.70	4.54	207.84
798 E	2.01	0.02	0.63	0.51	0.62	1.87	0.30	6.75	-8.00	7.62	4.16	467.62
841 E	2.12	0.15	0.85	0.80	0.29	1.98	-0.27	9.07	-7.17	2.53	2.97	289.83
929 E	2.04	0.21	0.81	1.02	0.32	1.88	-0.17	6.28	-8.43	1.28	2.51	489.91
96[illegible] F	1.44	0.66	0.53	1.14	0.69	1.32	-0.10	5.18	-3.07	0.51	1.78	229.00
038 F	2.15	0.12	1.15	1.39	0.45	2.01	-0.16	8.50	-5.91	0.92	2.70	315.27
055 F	1.88	0.07	0.51	0.77	0.27	1.76	0.01	4.34	-8.44	2.51	2.05	409.96
070 F	2.22	0.76	0.71	1.58	0.76	1.96	-0.40	7.96	-5.55	0.09	4.07	200.55
075 F	2.67	0.70	1.08	1.64	0.70	2.36	-0.33	11.38	-8.96	-6.17	4.42	438.51
077 F	2.20	0.29	0.72	1.29	0.44	2.04	0.01	8.60	-7.31	0.78	4.04	498.94
112 F	1.49	0.21	0.49	0.72	0.22	1.42	-0.32	5.36	-3.77	-1.14	1.78	180.81
247 F	1.82	0.18	0.46	0.84	0.30	1.70	-0.18	4.75	-4.41	0.84	2.56	249.02
265 F	1.85	0.18	0.59	1.16	0.41	1.75	-0.56	6.27	-5.37	0.47	2.18	218.13
333 F	1.30	0.27	0.51	0.94	0.38	1.27	-0.09	5.00	-2.85	1.23	1.52	295.28
363 F	1.95	0.18	0.78	0.88	0.56	1.86	0.19	8.08	-8.51	3.18	2.69	553.65
190 F	1.96	0.14	0.87	0.80	0.40	1.89	0.16	8.43	-8.84	4.33	2.07	551.79
411 F	1.61	0.06	0.65	0.94	0.43	1.54	-0.32	6.26	-5.03	1.03	1.80	245.26
580 F	2.01	0.33	0.86	1.00	0.39	1.85	-0.15	5.83	-7.28	1.27	2.52	446.77
893 F	1.13	0.57	0.40	0.93	0.73	1.12	0.18	4.86	-1.85	-0.28	0.64	371.45
901 F	2.16	0.03	0.75	0.86	0.22	1.98	-0.18	7.92	-8.61	2.21	4.89	205.40
Halifax Subjects												
146 A	1.97	0.04	0.80	1.03	0.50	1.84	-0.08	6.50	-7.79	2.35	2.35	450.18
1[illegible]8 A	2.16	0.02	1.01	1.09	0.72	1.95	-0.24	7.88	-6.86	4.86	4.30	442.75
159 A	2.03	0.07	1.03	1.16	0.56	1.82	-0.16	7.33	-7.40	2.08	4.04	577.79
329 A	2.35	0.79	1.13	1.55	0.77	2.04	-0.22	8.24	-6.96	-0.75	3.83	486.93
331 A	2.45	0.06	0.95	1.64	0.03	2.25	-0.14	7.45	-7.54	-2.79	3.30	491.44
340 A	1.76	0.04	0.75	0.60	0.32	1.66	-0.06	5.83	-7.78	3.79	2.08	406.68

Subject SIN & Group Halifax Subjects	Speed at Peak 1 Velocity m/s s1	Speed at Min 1 Velocity m/s s2	Speed at Peak 1 Acc/For m/s s3	Speed at Peak 2 Acc/For m/s s4	Speed at Peak 3 Acc/For m/s s5	Speed at Peak 1 Power m/s s6	Acc at Peak 1 Velocity m/s^2 a1	Acc at Peak 1 Acc/For m/s^2 a3	Acc at Peak 2 Acc/For m/s^2 a4	Acc at Peak 3 Acc/For m/s^2 a5	Acc at Peak 1 Power m/s^2 a6	Force at Peak 1 Velocity N f1
495 A	1.94	0.06	0.87	0.84	0.28	1.83	-0.34	6.18	-6.33	0.38	1.65	437.97
500 A	2.51	0.02	1.08	1.35	0.35	2.28	-0.22	7.97	-8.81	0.72	4.45	487.05
520 A	2.07	0.20	1.01	1.15	0.52	1.97	-0.13	8.11	-7.16	-0.16	2.38	403.97
608 A	2.16	0.12	1.10	1.02	0.47	1.97	-0.02	8.34	-8.41	2.84	3.34	452.79
809 A	2.74	0.04	1.35	1.78	0.04	2.05	0.12	10.84	-7.81	-0.32	7.86	459.51
812 A	1.81	0.03	0.74	1.09	0.58	1.64	0.14	5.95	-7.15	1.65	1.85	505.43
873 A	2.19	0.73	0.86	1.57	0.80	2.05	-0.20	6.79	-6.76	1.02	2.37	400.92
117 B	2.09	0.07	1.52	0.79	0.52	1.87	-0.16	6.18	-8.96	4.76	5.00	358.94
131 B	1.71	-0.02	0.86	0.65	0.32	1.60	0.03	5.79	-5.65	3.82	2.06	588.94
137 B	1.93	0.16	0.83	1.02	0.44	1.84	-0.13	6.82	-6.73	0.89	1.57	403.74
165 B	2.12	-0.02	0.88	0.78	0.30	1.94	-0.22	5.37	-9.47	3.40	3.97	530.69
367 B	2.16	0.12	1.04	0.95	0.25	1.96	-0.25	7.77	-9.17	2.11	2.43	615.48
420 B	2.28	0.19	0.59	1.14	0.24	2.08	0.03	4.82	-8.22	0.41	3.64	455.27
653 B	1.55	0.03	0.49	0.92	0.32	1.44	0.03	4.01	-4.11	2.47	2.06	321.21
658 B	2.30	.00	1.02	0.91	0.18	1.98	-0.31	8.66	-8.51	1.12	4.43	482.35
964 B	2.01	-0.05	0.95	0.58	0.60	1.92	-0.41	7.82	-7.63	7.93	1.97	605.71
968 B	2.19	0.30	0.84	1.24	0.36	2.00	0.01	7.17	-6.71	0.27	3.54	409.64
049 C	2.14	0.14	0.83	1.30	0.56	1.96	0.21	6.28	-8.49	0.92	3.43	509.13
102 C	2.28	0.28	1.04	1.06	0.28	2.09	-0.10	8.15	-7.32	-0.05	3.82	493.45
383 C	2.21	0.51	0.90	1.21	0.65	2.02	0.16	7.55	-6.78	1.13	3.57	415.96
493 C	2.00	0.51	0.77	1.06	0.78	1.86	0.07	5.50	-7.46	4.41	2.93	546.74
634 C	2.19	0.49	1.01	1.26	0.54	2.03	0.02	8.23	-7.59	0.92	3.36	365.68
775 C	2.16	0.02	0.88	1.08	0.78	2.00	-0.28	6.91	-7.63	8.96	3.58	484.17
790 C	2.53	0.61	1.27	1.70	0.61	1.90	-0.32	9.96	-7.32	-0.23	7.01	396.05
893 C	1.99	0.09	0.79	0.82	0.23	1.86	-0.12	7.17	-7.60	1.82	2.41	404.27
944 C	2.31	0.22	1.08	1.23	0.38	2.11	-0.20	7.98	-7.53	0.26	3.27	532.00
952 C	2.21	0.44	0.86	1.26	0.46	2.07	0.02	7.06	-7.94	0.24	2.64	410.15
099 D	2.17	0.68	1.04	1.44	0.71	2.02	0.12	8.57	-5.86	-0.14	2.86	189.14
158 D	1.98	0.25	0.82	1.22	0.49	1.84	0.11	6.68	-6.22	0.48	3.08	301.56
178 D	2.25	0.22	1.08	1.16	0.43	1.74	-0.07	9.40	-5.70	0.66	6.20	273.80
244 D	1.90	-0.02	1.03	0.65	0.47	1.51	-0.15	8.21	-7.77	3.73	6.14	249.74
404 D	2.01	0.17	0.73	1.01	0.30	1.86	-0.04	5.66	-6.36	-0.41	3.17	208.24
453 D	1.81	0.01	0.79	0.81	0.17	1.72	-0.16	6.20	-7.02	2.02	1.92	249.54
489 D	1.29	0.14	0.39	0.61	0.39	1.27	-0.08	3.21	-3.52	3.25	0.57	251.62
650 D	2.00	0.30	0.96	1.37	0.45	1.75	-0.42	8.19	-5.87	0.55	4.55	242.63
674 D	2.14	0.12	0.84	1.06	0.20	1.92	-0.32	6.38	-5.86	0.40	4.30	180.84
786 D	1.85	0.29	0.66	0.99	0.36	1.73	-0.13	6.00	-6.57	0.65	2.73	228.19
802 D	2.28	0.32	0.87	1.14	0.61	2.09	0.13	7.34	-8.11	1.04	4.10	256.99
047 Q	2.28	0.22	1.07	1.07	0.38	2.10	-0.10	7.55	-8.41	1.51	3.14	581.06
208 Q	2.07	-0.03	0.75	1.17	0.37	1.90	-0.08	6.50	-8.12	1.20	3.45	229.54
358 Q	2.02	0.23	0.89	1.33	0.88	1.88	-0.17	6.79	-7.82	3.14	3.34	620.89
414 Q	2.12	0.16	0.94	0.88	0.73	1.98	0.12	7.04	-8.82	8.09	2.80	842.49

Subject SIN & Group Kingston Subjects	Force at Peak 1 Acc/For N f3	Force at Peak 2 Acc/For N f4	Force at Peak 3 Acc/For N f5	Force at Peak 1 Power N f6	Power at Peak 1 Velocity Joules p1	Power at Peak 1 Acc/For Joules p3	Power at Peak 2 Acc/For Joules p4	Power at Peak 3 Acc/For Joules p5	Power at Peak 1 Power Joules p6	Power at Peak 2 Power Joules p7	Work for Six foot Lift N.m work	Ave. Vel. for Six Foot Lift m/s av vel
323 A	994.85	138.73	631.24	721.81	1095.42	861.14	176.16	124.23	1383.89	3.33	764.66	0.84
326 A	886.76	95.83	493.36	582.30	1039.75	727.76	101.59	76.57	1248.80	48.45	634.96	1.01
331 A	1318.67	65.01	834.04	1014.34	1516.90	1100.15	73.77	394.39	2107.15	67.93	951.85	1.06
363 A	544.31	108.84	435.14	379.26	557.59	458.12	90.84	204.74	661.84	-17.35	463.09	0.58
473 A	1150.71	66.40	1369.47	888.37	1226.48	908.55	42.48	1166.79	1504.31	42.08	902.64	1.21
547 A	480.69	12.02	297.48	402.09	637.49	399.07	14.63	108.16	889.68	16.11	361.44	1.07
625 A	547.47	13.45	335.74	427.32	706.63	448.83	11.46	94.34	933.66	11.46	414.17	0.90
629 A	1005.20	158.19	884.12	675.90	1018.86	879.39	93.52	666.71	1226.66	-47.07	772.46	1.05
648 A	424.47	53.46	253.28	360.27	539.36	294.03	62.86	93.49	726.29	59.98	328.42	0.78
702 A	959.19	-7.19	676.63	780.43	1340.32	749.78	-6.82	167.29	1744.81	-6.82	773.17	0.94
788 A	509.98	12.73	313.27	372.50	548.29	423.55	12.72	68.05	740.37	-3.27	355.85	0.58
800 A	736.54	187.77	433.96	539.12	873.08	537.26	231.69	58.96	1051.63	30.76	527.47	0.67
833 A	461.71	62.15	316.57	338.05	474.92	319.19	37.85	83.44	588.80	8.54	520.12	0.54
873 A	857.59	85.38	745.83	614.73	887.35	590.98	57.61	406.76	1076.85	79.25	1003.67	0.53
949 A	905.00	-22.74	558.82	549.73	911.80	1004.57	-27.68	366.60	1200.29	-31.44	567.17	1.18
034 B	1120.53	76.99	605.91	876.48	1425.63	795.09	108.03	266.87	1845.51	105.10	889.23	0.74
053 B	1110.24	42.47	695.48	777.35	1290.92	1035.47	41.84	306.95	1767.87	-2.21	766.38	0.95
093 B	1067.72	89.75	567.65	618.11	1061.69	1176.03	76.13	135.66	1238.84	72.43	687.94	0.91
191 B	1189.09	64.37	624.50	701.64	1384.88	1111.22	82.05	133.52	1565.90	78.59	817.24	0.80
250 B	876.10	97.52	504.40	664.39	1028.50	794.17	123.50	129.55	1366.54	54.41	635.70	0.89
426 B	1040.03	-0.97	565.97	786.54	1182.65	1284.90	-1.34	83.20	1965.76	-1.34	629.55	1.09
510 B	825.51	26.55	491.28	543.20	916.85	740.87	25.05	239.64	1131.05	25.05	581.43	1.11
710 B	885.97	106.63	498.45	670.52	1024.99	889.53	161.83	3.94	1464.24	-10.30	625.44	0.65
727 B	1174.08	178.45	639.73	823.60	1439.49	1024.12	241.36	192.16	1893.38	133.95	810.74	0.98
792 B	1077.43	106.02	557.76	687.68	1100.81	1186.25	108.96	264.65	1450.90	107.04	701.03	0.79
830 B	943.90	99.97	297.18	673.07	1174.85	895.78	160.37	180.90	1610.43	154.89	641.74	1.76
839 B	847.31	112.07	492.60	633.05	923.88	700.73	125.59	162.84	1135.78	120.81	631.19	0.93
959 B	1035.08	100.27	561.46	651.97	1027.32	1064.73	108.31	268.16	1240.08	99.20	689.24	0.84
960 B	1046.02	135.05	696.92	855.13	1340.95	812.38	142.46	187.47	1805.88	-2.61	828.67	0.79
081 C	1009.77	25.22	500.27	586.80	1133.57	1037.01	35.37	234.43	1355.45	35.37	636.77	1.33
126 C	1258.93	89.97	1057.98	1078.37	1167.39	1270.32	60.14	796.63	1567.14	11.95	843.39	1.21
284 C	938.04	94.29	611.21	809.87	1064.34	980.94	86.36	236.78	1246.50	15.62	860.33	0.63
429 C	1145.74	7.20	610.21	857.62	1436.23	1150.14	9.44	35.32	2064.72	9.44	753.10	0.65
520 C	1068.01	92.10	596.51	824.97	1365.86	965.90	131.94	330.27	1863.15	131.44	760.27	1.25
606 C	837.04	256.20	478.49	580.20	871.14	573.83	352.07	123.60	1063.55	82.97	637.77	0.76
633 C	883.09	153.87	446.97	786.11	982.16	960.28	199.14	198.05	1201.91	161.43	569.27	1.29
681 C	896.74	160.92	480.72	681.33	1103.03	663.25	162.34	139.35	1408.29	143.05	698.63	1.27
741 C	1013.32	66.75	450.05	723.51	1303.77	1009.14	101.24	245.19	1783.61	99.17	698.30	1.51
821 C	1061.43	89.73	324.55	683.98	1150.03	1252.42	150.11	165.24	1569.42	137.61	632.96	1.80
835 C	755.10	83.86	622.53	702.93	1111.82	451.03	84.96	219.38	1423.94	74.87	808.86	0.71
861 C	1101.40	50.42	543.59	852.90	1342.20	1096.50	46.30	189.00	1934.04	46.30	750.70	1.38
882 C	893.09	21.89	657.66	685.17	973.01	946.32	14.55	143.67	1273.65	-1.49	631.16	1.96
904 C	1103.47	-5.71	733.01	702.17	1106.66	1076.67	-4.40	592.59	1336.13	-15.17	765.34	0.80
015 D	693.65	143.28	599.41	545.60	845.45	645.74	150.00	294.76	1047.40	-12.21	771.78	0.68
202 D	873.10	130.73	468.91	620.89	1104.94	789.98	173.20	270.27	1324.04	161.22	634.40	1.54
376 D	886.29	88.55	346.92	654.91	1214.04	763.58	140.69	182.09	1581.95	140.69	641.29	1.68
404 D	1004.46	75.84	984.51	670.09	967.81	806.81	48.50	613.33	1104.55	-10.62	752.72	0.78

Subject SIN & Group	Force at Peak 1 Acc/For N f3	Force at Peak 2 Acc/For N f4	Force at Peak 3 Acc/For N f5	Force at Peak 1 Power N f6	Power at Peak 1 Velocity Joules p1	Power at Peak 1 Acc/For Joules p3	Power at Peak 2 Acc/For Joules p4	Power at Peak 3 Acc/For Joules p5	Power at Peak 1 Power Joules p6	Power at Peak 2 Power Joules p7	Work for Six Foot Lift N.m work	Ave. Vel. for Six Foot Lift m/s av vel
Kingston Subjects												
517 O	953.91	40.61	870.01	678.14	1184.43	1004.80	47.63	657.38	1469.95	44.24	746.75	0.79
549 D	931.69	112.61	485.62	699.64	1247.98	1101.22	175.97	209.12	1704.34	7.30	704.10	1.05
717 D	703.18	29.42	488.78	539.43	797.89	646.16	26.89	195.05	1065.98	26.31	520.65	0.96
732 O	877.19	19.17	525.86	632.25	1068.69	782.05	19.06	121.85	1356.44	0.42	644.12	0.89
743 D	862.98	33.93	640.25	609.12	854.93	704.91	32.28	305.18	1087.87	32.28	645.76	0.63
855 O	1288.53	0.93	639.55	955.90	1569.08	1216.93	1.28	145.61	2203.31	1.28	880.68	1.19
958 O	955.62	56.33	694.70	685.30	1008.49	801.76	35.53	235.88	1234.79	12.87	705.81	1.03
003 E	633.49	107.06	681.50	545.85	731.28	255.05	72.34	241.49	812.68	-3.88	651.55	0.90
166 E	584.05	115.92	307.01	501.71	647.94	689.59	176.13	-2.87	853.53	-7.89	414.02	0.72
207 E	1090.92	104.39	682.08	755.20	1200.94	966.44	75.59	268.02	1510.50	75.59	760.97	1.03
243 E	334.29	113.82	313.31	282.76	368.81	153.41	52.61	92.45	418.40	21.88	324.65	0.65
266 E	601.61	66.84	325.77	428.78	764.17	757.75	92.42	154.41	983.08	-10.13	556.27	0.67
389 E	415.12	134.59	344.65	325.73	430.55	193.01	114.95	196.32	479.60	101.95	394.38	0.93
607 E	798.96	69.62	459.10	573.49	1035.53	876.61	105.69	164.26	1314.49	98.52	662.55	1.01
625 E	1120.14	112.55	569.21	742.90	1391.43	1174.04	153.02	153.50	1796.90	98.71	748.71	1.10
630 E	419.22	88.78	249.63	324.85	518.13	409.76	119.74	60.84	665.07	5.61	342.71	0.70
688 E	911.61	24.92	558.28	619.53	1138.70	855.94	30.24	150.36	1484.91	30.24	639.08	1.14
721 E	426.50	47.35	245.44	305.96	476.84	390.71	73.36	136.52	626.00	71.40	295.88	1.14
798 E	766.32	83.89	806.29	646.40	938.93	481.28	43.13	500.44	1210.22	8.55	656.52	1.10
841 E	573.78	80.31	374.98	388.30	614.10	485.73	64.12	109.11	768.23	42.27	416.57	0.73
929 E	817.52	70.10	563.14	626.06	1000.83	659.59	71.61	178.02	1178.30	69.92	812.48	0.83
967 E	353.40	159.04	243.31	273.39	329.92	188.30	181.93	168.24	360.98	81.63	328.65	0.87
038 F	597.86	127.30	350.35	408.52	677.80	688.01	176.81	158.50	819.35	36.41	479.68	0.70
055 F	590.37	57.32	514.04	494.76	770.77	299.98	44.35	137.42	872.44	27.35	623.28	0.67
070 F	378.86	90.84	211.11	296.01	444.66	268.26	143.28	159.89	580.75	140.08	300.07	1.40
075 F	980.67	39.50	168.60	658.36	1172.01	1062.01	64.72	117.18	1550.78	64.72	641.82	1.90
077 F	935.26	127.06	538.10	703.75	1099.36	676.81	163.29	238.63	1432.62	160.20	706.35	0.85
112 F	289.06	115.03	165.09	220.77	269.45	142.18	83.23	37.14	314.39	42.27	389.42	0.54
247 F	376.39	139.47	275.33	319.66	454.13	174.68	116.68	83.15	544.69	43.64	359.19	0.75
265 F	379.26	104.70	242.52	282.78	404.35	225.24	121.38	99.25	494.93	40.39	327.98	0.68
333 F	450.07	211.51	335.39	344.22	385.08	230.18	198.05	127.49	435.48	86.21	545.63	0.49
363 F	990.13	72.20	718.90	691.84	1077.47	767.47	63.54	401.47	1287.05	-12.16	766.67	0.69
390 F	1009.29	53.58	782.44	657.48	1083.72	877.48	42.79	309.57	1240.99	40.26	762.80	1.05
411 F	415.30	123.51	280.15	300.03	394.06	269.55	115.74	120.92	461.56	92.90	461.36	0.49
580 F	723.82	116.97	512.63	570.74	899.75	620.25	116.49	202.38	1057.94	21.81	700.09	0.95
893 F	545.65	296.08	354.48	388.75	420.20	219.77	274.53	258.08	435.10	216.80	523.37	0.87
901 F	378.10	25.53	256.35	313.32	444.30	282.15	21.87	57.12	620.03	6.41	293.62	0.81
Halifax Subjects												
146 A	754.85	93.67	562.69	562.57	885.37	604.36	96.67	281.65	1033.67	26.87	674.80	0.93
158 A	818.72	136.55	678.57	652.66	958.25	828.93	148.99	490.47	1269.89	9.92	738.76	0.63
159 A	1026.38	144.32	711.77	829.02	1174.49	1057.56	167.63	397.46	1510.51	28.59	962.17	0.60
329 A	916.94	144.68	460.23	692.67	1143.80	1032.41	224.78	355.49	1412.87	213.75	773.43	1.23
331 A	876.88	115.23	356.47	666.18	1205.16	829.26	188.75	11.06	1498.80	11.06	702.05	1.39
340 A	652.69	84.73	567.39	496.25	717.24	490.10	50.90	181.69	826.07	14.51	752.01	0.67

Subject SIN & Group Halifax Subjects	Force at Peak 1 Acc/For N f3	Force at Peak 2 Acc/For N f4	Force at Peak 3 Acc/For N f5	Force at Peak 1 Power N f6	Power at Peak 1 Velocity Joules p1	Power at Peak 1 Acc/For Joules p3	Power at Peak 2 Acc/For Joules p4	Power at Peak 3 Acc/For Joules p5	Power at Peak 1 Power Joules p6	Power at Peak 2 Powor Joulos p7	Work for Six Foot Lift N.m work	Ave. Vel. for Six Foot Lift m/s av vel
495 A	739.95	161.22	471.63	530.41	847.98	646.18	134.82	133.24	972.63	14.61	701.47	0.85
500 A	903.36	30.61	534.78	724.47	1222.98	978.48	68.50	187.19	1650.63	68.50	740.86	1.04
520 A	747.63	110.53	402.51	508.63	838.16	752.07	127.56	208.28	1002.30	83.10	629.55	0.70
608 A	839.68	64.96	585.27	608.34	979.87	920.33	66.49	273.87	1196.92	54.27	674.45	0.70
809 A	955.54	92.43	438.92	817.46	1259.86	1287.32	164.12	17.89	1671.90	7.92	671.85	1.17
812 A	800.79	135.35	582.32	592.26	913.93	591.36	147.67	337.01	972.27	3.94	780.72	0.71
873 A	692.91	127.36	451.98	508.08	876.51	598.36	200.12	362.70	1041.94	195.82	653.01	1.21
117 B	594.64	31.76	541.69	550.62	749.28	904.25	25.18	283.08	1031.61	25.62	571.43	0.66
131 B	933.83	249.28	815.90	710.41	1005.86	799.39	162.07	264.21	1137.33	-14.56	941.45	0.59
137 B	694.00	128.58	446.38	475.02	779.98	579.45	131.14	198.48	875.51	64.95	615.08	0.65
165 B	839.85	18.58	730.98	762.38	1127.40	738.83	14.43	218.73	1482.06	-11.52	725.08	0.68
367 B	1132.31	41.44	767.97	788.18	1329.80	1174.56	39.29	193.94	1545.47	37.86	977.58	0.78
420 B	676.82	73.58	472.68	622.50	1038.37	396.21	83.80	111.47	1292.83	75.34	693.49	0.70
653 B	451.21	186.06	401.02	387.65	497.68	223.19	171.98	127.23	559.81	9.61	447.21	0.59
658 B	938.32	65.92	555.22	723.44	1108.93	955.85	60.08	99.58	1433.89	-2.22	715.78	0.62
964 B	1135.58	140.63	1142.42	758.64	1214.54	1076.08	81.87	689.94	1458.27	-35.47	943.29	1.05
968 B	708.45	129.51	420.83	557.00	896.08	597.44	160.16	152.76	1111.98	121.33	606.56	0.83
049 C	817.34	67.20	545.05	672.51	1088.40	681.25	87.68	303.82	1316.26	84.77	751.30	0.65
102 C	912.17	126.52	495.85	692.32	1126.96	946.44	134.04	139.92	1445.39	120.10	757.60	0.69
383 C	724.56	125.42	456.66	558.24	920.06	652.49	152.62	295.74	1129.16	146.91	622.12	0.99
493 C	847.15	129.99	787.08	704.80	1095.66	652.61	138.40	615.18	1312.22	129.70	787.98	0.97
634 C	671.03	82.45	399.13	489.63	799.50	677.31	103.95	215.11	991.90	99.09	539.27	0.82
775 C	849.59	110.84	953.50	680.22	1043.43	746.12	119.55	745.29	1359.02	12.71	772.37	0.79
790 C	825.03	103.92	399.73	701.98	1002.31	1047.91	176.30	244.16	1334.95	170.85	657.84	1.34
893 C	708.48	92.35	485.35	509.76	803.21	562.96	75.61	110.67	947.45	35.89	758.94	0.68
944 C	984.60	125.94	557.27	723.87	1230.11	1063.95	154.71	209.03	1525.37	118.12	840.80	0.71
952 C	703.99	78.07	419.39	519.66	907.07	602.79	98.03	191.64	1077.08	96.18	619.57	0.96
099 D	350.20	75.21	184.20	241.30	409.92	365.53	108.42	130.78	488.56	103.65	267.88	1.24
158 D	501.20	109.14	312.65	391.63	598.55	411.64	133.34	153.58	720.45	73.73	453.89	0.70
178 D	540.18	115.49	294.45	450.32	616.84	581.28	133.56	127.66	784.89	59.23	436.44	0.75
244 D	465.79	52.78	350.03	412.40	474.19	481.55	34.32	165.77	622.41	-4.35	356.00	0.58
404 D	329.84	73.50	200.44	276.79	417.75	242.10	73.93	60.23	513.68	35.14	314.65	0.60
453 D	413.76	72.14	305.73	303.18	452.79	326.47	58.20	50.90	521.62	2.13	429.24	0.62
489 D	336.65	162.57	337.53	268.25	324.60	132.79	99.13	132.49	339.69	33.81	456.05	0.65
650 D	465.23	101.84	267.69	371.08	484.05	448.90	139.24	121.04	651.03	94.67	369.77	0.72
674 D	308.51	75.26	194.54	268.86	386.52	259.54	79.45	39.47	515.55	22.53	321.18	0.63
786 D	372.73	76.40	246.72	295.58	421.19	245.99	75.65	88.16	511.79	63.63	368.00	0.72
802 D	443.34	43.82	280.53	359.54	584.96	384.68	49.80	169.86	750.77	47.66	393.25	0.90
047 Q	1039.13	83.57	677.84	775.35	1325.38	1109.65	89.19	258.47	1624.97	84.85	870.91	0.63
208 Q	384.53	39.75	259.70	312.73	476.17	288.66	46.53	95.46	594.69	43.57	435.24	0.68
358 Q	1069.42	128.45	834.07	846.67	1257.05	953.80	170.22	736.24	1589.32	142.02	1181.38	0.68
414 Q	1428.92	84.08	1518.49	1069.96	1785.07	1338.26	74.38	1109.03	2119.65	73.01	1211.52	1.07

Subject S/N & Group	Average Acc. m/s^2 acc	Average Force N force	Average Power Joules power
Kingston Subjects			
323 A	0.05	546.18	460.64
326 A	-0.12	448.22	456.80
331 A	-0.07	670.97	715.68
363 A	0.08	300.62	182.32
473 A	0.26	648.32	771.49
547 A	0.18	258.36	273.82
625 A	-0.10	295.19	267.21
629 A	0.20	554.13	576.46
648 A	0.09	233.34	182.46
702 A	0.16	552.03	515.45
788 A	-0.02	253.01	147.65
800 A	-0.12	404.47	271.31
833 A	-0.97	228.56	203.17
873 A	-1.02	446.10	392.06
949 A	-0.24	399.22	476.61
034 B	0.01	632.76	465.57
053 B	0.03	544.35	517.83
093 B	-0.27	484.74	449.63
191 B	-0.13	579.48	464.34
250 B	-0.09	449.82	402.34
476 B	-0.18	445.43	491.83
510 B	0.11	414.15	457.82
710 B	-0.18	445.42	289.55
727 B	-0.32	568.40	570.95
792 B	0.02	499.23	393.84
830 B	0.20	462.94	802.18
839 B	-0.09	449.91	420.79
959 B	-0.27	484.80	412.72
960 B	-0.02	586.24	465.55
081 C	-0.03	452.31	600.72
126 C	0.26	602.74	720.85
284 C	0.35	516.31	338.71
429 C	-0.17	533.70	350.28
520 C	-0.08	538.46	678.81
606 C	-0.05	451.43	344.74
633 C	-0.11	404.58	527.10
681 C	-0.11	492.62	629.40
741 C	-0.11	490.87	750.86
821 C	-0.23	443.25	811.49
835 C	-0.08	494.20	353.22
861 C	-0.32	525.42	743.27
882 C	-0.09	449.59	478.15
904 C	0.02	544.26	434.86
015 D	0.41	426.66	303.85
202 D	-0.04	452.17	697.15
376 D	0.09	458.26	763.44
404 D	-0.15	534.76	422.88

Subject SIN & Group	Average Acc. m/s^2 acc	Average Force N force	Average Power Joules power
Kingston Subjects			
517 D	-0.27	484.87	388.93
549 D	-0.29	440.34	472.55
717 D	0.22	373.03	356.61
732 D	0.08	457.69	407.67
743 D	0.08	457.80	289.58
855 D	-0.33	610.50	746.34
958 D	0.16	506.38	515.19
003 E	0.26	465.81	415.00
166 E	-0.31	288.77	212.32
207 E	-0.04	540.44	555.46
243 E	-0.04	230.30	150.30
266 E	0.59	316.06	220.74
389 E	0.24	282.65	259.46
607 E	-0.27	398.13	408.98
625 E	-0.29	526.66	589.53
630 E	-0.18	227.03	160.14
688 E	0.12	459.49	519.58
721 E	0.10	211.34	240.55
798 E	0.41	472.94	508.93
841 F	-0.08	295.66	218.10
929 E	-0.22	487.39	410.34
962 E	0.06	232.76	202.87
038 F	-0.28	311.40	220.04
055 F	-0.09	405.42	274.57
070 F	0.36	216.90	297.10
075 F	0.15	460.97	867.33
077 F	0.06	501.37	422.96
112 F	-0.93	169.13	150.95
247 F	0.02	254.01	191.06
265 F	0.03	232.12	158.44
333 F	-0.87	271.71	213.14
363 F	0.03	544.79	373.99
390 F	0.02	544.15	569.25
411 F	-0.88	230.77	180.22
580 F	-0.31	439.78	426.88
893 F	0.22	372.92	319.13
901 F	-0.06	207.83	169.72
Halifax Subjects			
146 A	-0.26	441.86	421.75
158 A	0.41	472.86	310.53
159 A	0.37	609.75	378.81
329 A	-0.43	476.75	604.24
331 A	-0.49	473.53	688.29
340 A	0.45	428.16	296.07

Subject SIN & Group	Average Acc. m/s^2 acc	Average Force N force	Average Power Joules power
Halifax Subjects			
495 A	-0.28	440.82	381.24
500 A	-0.36	480.04	510.94
520 A	-0.26	398.41	283.58
608 A	-0.30	439.98	312.25
809 A	-0.56	428.14	520.81
812 A	-0.17	489.66	351.68
873 A	-0.25	398.83	494.70
117 B	-0.09	361.63	241.11
131 B	0.38	609.89	370.65
137 B	-0.18	402.01	263.98
165 B	-0.23	530.41	366.20
367 B	-0.27	614.39	405.36
420 B	-0.09	449.51	315.22
653 B	-0.16	315.05	187.90
658 B	-0.22	486.96	307.20
964 B	-0.39	606.96	655.06
968 B	-0.19	401.35	336.98
049 C	-0.15	490.56	321.07
102 C	-0.25	485.41	339.73
383 C	-0.25	399.08	403.97
493 C	-0.25	529.16	521.84
634 C	-0.29	354.12	294.69
775 C	-0.19	488.84	390.09
790 C	-0.35	394.96	543.67
893 C	0.42	426.82	298.80
944 C	-0.28	527.47	380.45
952 C	-0.25	399.06	389.67
099 D	-0.40	179.28	228.96
158 D	-0.19	292.37	206.31
178 D	-0.23	269.44	205.87
244 D	-0.16	249.49	146.50
404 D	0.13	211.86	128.43
453 D	0.41	264.20	158.99
489 D	0.55	267.71	179.55
650 D	-0.22	247.81	182.15
674 D	0.44	195.30	126.45
786 D	-0.13	228.35	165.76
802 D	-0.25	247.17	226.00
047 Q	-0.27	570.96	365.93
208 Q	0.60	245.41	172.03
358 Q	0.52	665.22	466.95
414 Q	-0.36	801.22	884.32

APPENDIX F

Individual Subject Materials

Contained in each subject portfolio were :

1. Personal Data Recording Sheets
2. Overview of MPFS Study
3. Schedules for Kingston/Halifax
4. General Body Warmup Exercises
5. Fitness Information

MINIMUM PHYSICAL FITNESS STANDARDS STUDY

Personal Data Summary Sheet

Name________________________________. Last Three ______.

Group___________.

STATION 1. FITNESS TESTING STATION

TEST 1. Incremental Lifting Machine. 6ft _______ kg.

5ft _______ kg.

TEST 2. Aerobic Leg Ergometer. _________ kg-m/min.

TEST 3. Anaerobic Leg Ergometer. _________ kg-m/min.

Lactate Sample. _________ ( )

TEST 4. Anaerobic Arm Ergometer. _________ kg-m/min.

TEST 5. Body Fat. _________ %

TEST 6. Flexed Arm Hang _________ s.

TEST 7. Endurance Grip (R) _________ s.

(L) _________ s.

STATION 2. LOW-HIGH CRAWL

TEST 1. Total Time _________ s.

TEST 2. Blood Lactate _________ s.

STATION 3. ENTRENCHMENT DIG

TEST 1. Total Time _________ s.

STATION 4. LAND STRETCHER CARRY

TEST 1. Total Time _________ min.

SCHOOL of PHYSICAL and HEALTH EDUCATION

QUEEN'S UNIVERSITY

MINIMUM PHYSICAL FITNESS STANDARDS STUDY

PREAMBLE

The Canadian Armed Forces (CF) are currently developing Minimum Physical Fitness Standards (MPFS) for all military personnel. The underlying principle is that there are certain duties which all personnel, even those in otherwise sedentary jobs, must be able to perform if called upon in an emergency. Seven common tasks have been identified by the CF as being critical. Queen's University has been contracted to investigate the specific fitness requirements of the most difficult tasks.

COMMON TASKS WITH FITNESS COMPONENT

Based on preliminary testing in CFB Kingston, Halifax and Queen's University, the most physically demanding tasks have been identified. These tasks will be performed by military personnel in Kingston from July 8-13, 1985 and in Halifax from July 15-19, 1985. The tasks are:

1) Two person team, using a stretcher will evacuate a normal person (80 kg.) across rough terrain a distance of 1 km. (CFB Kingston)

2) Each person will dig a one-person foxhole 6 ft. long, 2 ft. wide and to a depth of 18 in. in soil of moderate firmness with no rocks or large roots. (CFB Kingston)

3) Each soldier must do a low crawl (all body parts close to the ground) for 30 m, turn 180 degrees, and do a high crawl (on hands and knees) for 45 m. (CFB Kingston)

4) Two person team will move a stretcher with an 80 kg person, while in fire-fighting gear, a horizontal distance of 25 m followed by moving the stretcher up and down one deck. (CFB Halifax)

5) In fire-fighting gear and using breathing apparatus and in varying temperatures, control 50 ft. (15 m) of charged hose for 30 minutes climbing and descending one deck. (CFB Halifax)

PURPOSE

The purpose of this study is to identify and quantify those components of physical fitness involved in performing these tasks. Performance on common tasks will be compared to performance on standard test batteries.

TEST BATTERIES

In addition to assessing the physiological and biomechanical demands of the aforementioned tasks, military personnel will be asked to perform two test batteries which may be used to predict field test performance. These test batteries are:

6) Canadian Forces EX-PRES test which consists of height, weight, blood-pressure, step-test, grip strength and push-ups. (CFB Kingston and Halifax)

7) Queen's University tests which consist of ILM tests, arm ergometer test, leg ergometer tests, flexed-arm hang, aerobic fitness test, percent body fat and endurance grip strength. (CFB Kingston and Halifax)

During these tasks, heart rate and other cardiovascular or muscle strength and endurance measures will be monitored by means of standard laboratory techniques. A venous blood sample will be extracted for lactate analysis by Dr. John Thomson following performance of selected military tasks or tests. In addition, some subjects will be filmed during their tests.

Thank-you for your participation in the development of physical fitness standards for the military.

MINIMUM PYSICAL FITNESS STANDARDS STUDY for the CANADIAN FORCES

conducted by QUEEN'S UNIVERSITY SCHOOL of PHYS. ED.

Kingston Schedules

Trenton Personnel

Group A:

Monday July 8

8:30- 9:00	Check in
9:00-11:30	Station 1 - Queen's Station (centre tent)
11:30- 1:00	Lunch
1:00- 4:00	Station 2 - Evacuation Task (track)

Tuesday July 9

8:30-11:30	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 4 - Entrenchment Dig (field)
5:00	Departure

Group B:

Monday July 8

8:30- 9:00	Check in
9:00-11:30	Station 4 - Entrenchment Dig (field)
11:30- 1:00	Lunch
1:00- 4:00	Station 1 - Queen's Station (centre tent)

Tuesday July 9

8:30-11:30	Station 2 - Evacuation task (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
5:00	Departure

Kingston Personnel - Land OPS

Group C:

Tuesday July 9

8:30- 9:00	Check in
9:00-11:30	Station 1 - Queen's Station (centre tent)
11:30- 1:00	Lunch
1:00- 4:00	Station 2 - Evacuation Task (track)

Wednesday July 10

8:30-11:30	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 4 - Entrenchment Dig (field)
5:	Departure

Group D:

Tuesday July 9
8:30- 9:00 Check in
9:00-11:30 Station 4 - Entrenchment Dig (field)
11:30- 1:00 Lunch
1:00- 4:00 Station 1 - Queen's Station (centre tent)

Wednesday July 10
8:30-11:30 Station 2 - Evacuation task (track)
11:30- 1:00 Lunch
1:00- 4:00 Station 3 - Low-High Crawl Task (centre track)
Station 2 - Evacuation Task repeats (track)
5:00 Departure

Kingston Personnel - Support

Group E:

Wednesday July 10
8:30- 9:00 Check in
9:00-11:30 Station 1 - Queen's Station (centre tent)
11:30- 1:00 Lunch
1:00- 4:00 Station 2 - Evacuation Task (track)

Thursday July 11
8:30-11:30 Station 3 - Low-High Crawl Task (centre track)
Station 2 - Evacuation Task repeats (track)
11:30- 1:00 Lunch
1:00- 4:00 Station 4 - Entrenchment Dig (field)
5:00 Departure

Group F:

Wednesday July 10
8:30- 9:00 Check in
9:00-11:30 Station 4 - Entrenchment Dig (field)
11:30- 1:00 Lunch
1:00- 4:00 Station 1 - Queen's Station (centre tent)

Thursday July 11
8:30-11:30 Station 2 - Evacuation task (track)
11:30- 1:00 Lunch
1:00- 4:00 Station 4 - Low-High Crawl Task (centre track)
Station 2 - Evacuation Task repeats (track)
5:00 Departure

MINIMUM PHYSICAL FITNESS STANDARDS STUDY for the MILITARY

conducted by QUEEN'S UNIVERSITY SCHOOL of PHYS. ED.

Halifax Schedules

Sea OPS Personnel

Group A:

Monday July 15
8:30- 9:00 Check in
9:00-11:30 Teaching - Fire-fighting (upper equipment building)
11:30- 1:00 Lunch
1:00- 4:00 Station 1 - Fire-fighting test (bulkhead 1)

Tuesday July 16
8:30-11:30 Station 2 - Queen's Station (lower equipment building)
11:30- 1:00 Lunch
1:00- 4:00 Station 3 - Shipboard Evacuation Task (bulkhead 2)
5:00 Departure

Group B:

Monday July 15
12:30- 1:00 Check in
1:00- 4:30 Teaching - Fire-fighting (upper equipment building)

Tuesday July 16
8:30-11:30 Station 1 - Fire-fighting Task (bulkhead 1)
11:30- 1:00 Lunch
1:00- 4:00 Station 2 - Queen's Station (lower equipment building)

Wednesday July 17
8:30-11:30 Station 3 - Shipboard Evacuation Task (bulkhead 2)
12:00 Departure

Support Personnel

Group C:

Tuesday July 15
8:30- 9:00 Check in
9:00-11:30 Teaching - Fire-fighting (upper equipment building)
11:30- 1:00 Lunch
1:00- 4:00 Station 1 - Fire-fighting test (bulkhead 1)

Wednesday July 16
8:30-11:30 Station 2 - Queen's Station (lower equipment building)
11:30- 1:00 Lunch
1:00- 4:00 Station 3 - Shipboard Evacuation Task (bulkhead 2)
5:00 Departure

Group D:

Tuesday July 16
12:30- 1:00 Check in
1:00- 4:30 Teaching - Fire-fighting (upper equipment building)

Wednesday July 17
8:30-11:30 Station 1 - Fire-fighting Task (bulkhead 1)
11:30- 1:00 Lunch
1:00- 4:00 Station 2 - Queen's Station (lower equipment building)

Thursday July 18
8:30-11:30 Station 3 - Shipboard Evacuation Task (bulkhead 2)
12:00 Departure

INJURY FREE FITNESS

[illegible]

1

TAKE RESPONSIBILITY FOR YOUR OWN FITNESS

[illegible]

Taking responsibility means:

- Working at your own pace and keeping the intensity of your workout at a level that suits your personal target zone
- Listening to your body and easing off on any activity that hurts
- Balancing your fitness program to ensure that you develop aerobic fitness, muscular fitness, and flexibility
- Learning and applying fundamental fitness principles.

2

FOLLOW THE PRINCIPLE OF PROGRESSIVE OVERLOAD

[illegible]

3

VARY YOUR ACTIVITIES

This rule applies to any individual session of activity or to your whole program. Its aim is to encourage balanced, overall fitness development and to prevent injuries from overuse.

Within one session, activity can be varied in many ways. Swimmers can switch strokes. Runners can speed up and slow down, make a lot of ... lightly backwards or sideways. In dance exercise you can vary your steps or the way your feet strike the ground. The aim in all cases is to spread the stress of activity over a broader range of muscles.

Within a program, varying activities ensures development of all muscle groups and gives particular muscles a chance to rest and adapt while others are working. For example, if you cycle one day and swim the next, you alternate between using the muscles of the lower and upper body. Hence you get balanced development and avoid injuries caused by using the same muscles workout after workout.

4

STAY WITHIN THE NORMAL RANGE OF MOTION OF YOUR JOINTS

The action that bends a joint is called flexion. The action that straightens a joint is called extension. It's important to exercise joints through their full range of motion. This helps to keep them well lubricated, mobile, healthy and strong.

However, it is possible to push joints past their normal range of motion, to either hyperextend or hyperflex them. This is when injuries occur. Outside its normal range, a joint no longer has the support and protection of surrounding muscles. This puts potentially injurious stress on the ligaments which hold bones together at joints.

One of the easiest ways a joint can be pushed too far is by ballistic motion, motion in which a limb or part of the body is thrown into motion, rather than being moved under control of the muscles. Momentum then pushes the joint past its normal range.

5

MAINTAIN PROPER POSTURE

In good posture the parts of your body are lined up so that you can move or hold yourself erect with the least possible effort and strain. In good posture the neck is held straight, the pelvis is tilted and tucked in, the curvature of the lower back is minimized, the knees are centred over the feet, and the centre of gravity of the body is held over the base of support. It's as if your whole body were hanging straight down from a thread attached to the top of your head.

Bad static posture, standing or sitting, is associated with many chronic problems such as lower back pain. Bad dynamic posture – the improper alignment of the body in motion – is a significant cause of injury. When the body in motion is not well aligned, strong twisting and ballistic forces can be generated which carry joints past their normal range of motion or throw the body dangerously off balance. To prevent injury, therefore, it's important to be aware of postural principles and apply them while exercising.

6

WARM UP AND COOL DOWN

[illegible]

Bad Moves

[illegible]

Bad Moves

[illegible]

Bad Moves

[illegible]

Bad Moves

[illegible]

Bad Moves

[illegible]

Bad Moves

[illegible]

NETWORK

Warm-up

Definition. The first phase of an exercise session is the warm-up. This 5-to-10-minute session should activate the physiological systems in preparation for the more vigorous exercise to come.

Importance. There are a number of important reasons for including a warm-up in an exercise prescription. First, you should be mentally prepared for the exercises that are to follow, just as the elite athlete works hard, mentally as well as physically, prior to competition in order to perform his or her best. Further, increasing your body temperature by warming up reduces the incidence of injury to muscles and joints in subsequent strenuous exercise. The warm-up should also be designed so that it stretches out your muscles and allows your joints to move through their complete range of motion.

Prescription Principles. This phase of the exercise session should range from a light to a moderate level of intensity. The session should be divided into two parts: aerobic activities and stretching exercises.

1. The aerobic activities should be of low intensity, their speed and frequency dependent on your fitness level. The activities should be sufficient only to increase body temperature to the point where you feel warmer; any sweating at this point will be the result more of environmental conditions than of the activity itself (see Chapter 5).
2. The stretching exercises should be performed slowly and carefully. Select exercises that stretch all of the major joints and muscle groups of the body through their natural range of motion. Each exercise should be performed rhythmically (avoid bobbing and jerking) up to ten times. Or, if you prefer, hold the stretch position for 10 to 20 seconds, and repeat up to 5 times.

Prescription. The following aerobic and stretching exercises for the warm-up phase are only suggestions. The first is a normal warm-up for the less physically fit; the second is more suitable for active, physically fit people. The exercises may be replaced, modified, or expanded to include skipping, swimming, or some other activity, as long as the objectives for warm-up exercises are met.

Example of Aerobic Warm-up. The most common aerobic warm-up is a sequence of slow walking – walking – brisk walking – jogging – steady running etc. However, a number of other innovative warm-ups can be developed, depending upon the facilities. In the house, for example, the following sequence is possible: walking up 1 to 5 flights of stairs (walk down) – slow running up stairs (walk down) – continuous two-leg jumping up stairs (walk down) – etc. Similar warm-up sequences can be devised for mediums such as water and snow.

Specific Flexibility Exercises. *Do not* overstretch—these are warm-up exercises.

For the Neck:

Exercise 1: Neck Rotator. Keeping the eyes focused forward and holding the chin in toward the neck, move the head slowly in a circular pattern, first in one direction and then in the other (Figure 8.2a). (Stretches neck rotators—flexors and extensors.) *Note:* If you have neck problems, avoid these exercises unless you are directed to perform them by a physician.

Exercise 2: Neck Twists. Turn the face slowly to the left and then to the right; repeat several times (Figure 8.2b). Stretches neck rotators—flexors and extensors.)

FIGURE 8.2 FIGURE 8.2

For the Trunk:

Exercise 1: Twister. Standing with feet apart and arms abducted sideways, twist to the left with arms and face moving in the same direction (Figure 8.3), and then twist to the right. Repeat slowly and rhythmically 5 to 20 times. (Stretches neck and trunk rotators.)

Exercise 2: Side Bender. Standing with feet apart and hands on head, bend slowly from side to side in the frontal plane (Figure 8.4). Repeat 5 to 10 times. (Stretches lateral benders of trunk.)

Exercise 3: Front Bends. Standing with feet together (Figure 8.5a), fully flex the neck, trunk, and hips and slightly flex the knees (Figure 8.5b). Extend, and repeat 5 to 10 times. (Stretches trunk, neck, and hip extensors.)

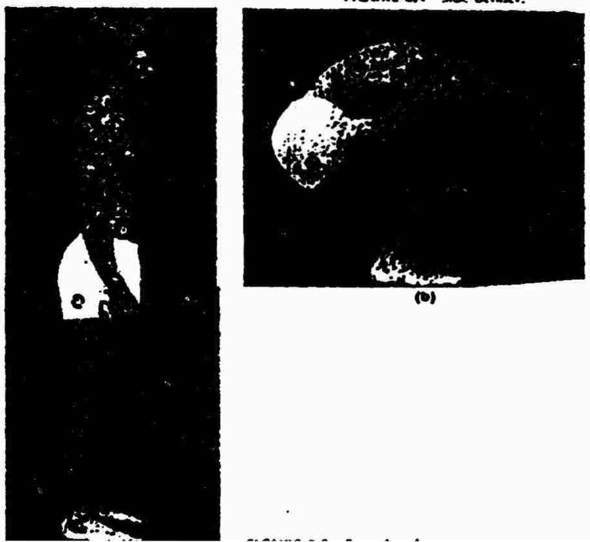
For the Legs:

Exercise 1: Hamstring Stretcher. Sitting on the floor with legs straight and spaced, reach for one ankle and hold; do the same with the other ankle (Figure 8.6). Repeat 5 to 10 times. (Stretches hip extensors and knee flexors.)

Exercise 2: Lateral Stretcher. Standing with legs wide apart and hands on hips, bend left leg and move body weight to the left; hold, and then shift weight over to the other foot (right knee bent) (Figure 8.7). Repeat 5 to 10 times. (Stretches hip adductors.)

FIGURE 8.3 Twister.

FIGURE 8.4 Side bender.



(b)

FIGURE 8.6 Hamstring stretcher

FIGURE 8.7 Lateral stretcher.

Exercise 3: Front Stretcher. Keep hands on hips. Placing one leg (knee bent) well forward of the other (Figure 8.8) and keeping the other leg straight with ankle dorsiflexed, slowly move forward and hold for several seconds. Repeat 5 to 10 times for both sides. (Stretches the hip flexors, knee extensors, and ankle dorsi flexors.)

For the Shoulders:

Exercise 1: Arm Circles. Standing with feet apart, perform slow, full-arm circles backward 5 to 10 times, then forward the same number of times. The arms should brush past the ears and the sides of the trunk (Figure 8.9). (Stretches the muscles crossing the shoulder joints.)

Exercise 2: Pull-Throughs. Standing with feet apart, flex one arm (straight) forward to shoulder level, extend the other arm backward to shoulder level, then swing both arms down and through so that they reverse positions (Figure 8.10). Repeat rhythmically 10 to 20 times, gradually increasing the vigor of the

FIGURE 8.8 Front stretcher

FIGURE 8.9 Arm circles

pull-through and the flexion and extension of the shoulders. (Stretches muscles crossing the shoulder joints.)

APPENDIX G

Manual of Schedules and Protocols

The manual contained the following information :

1. Introduction
2. Schedules for C.F.B. Kingston
3. Schedules for C.F.B. Halifax
4. Protocols of Stations

    Queen's Station

    Land Stretcher Carry

    Low-High Crawl

    Entrenchment Dig

    Teaching Fire Fighting

    Fire Fighting

    Sea Stretcher Carry

MANUAL OF SCHEDULES AND PROTOCOLS

C.F.B. KINGSTON JULY 8-13, 1985

C.F.B. HALIFAX JULY 15-19, 1985

FOR DEVELOPMENT OF A TEST BATTERY FOR MINIMUM PHYSICAL FITNESS STANDARDS FOR USE BY THE CANADIAN FORCES

developed by

QUEEN'S UNIVERSITY AT KINGSTON.

Principal Investigators

Joan M. Stevenson, Ph.D.
School of Physical and Health Education

George M. Andrew, Ph.D.
School of Physical and Health Education

J. Timothy Bryant, Ph.D.
Department of Mechanical Engineering

John M. Thomson, Ph.D.
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Research Assistants

Sheryl French-Scott   Timothy Lapp

Christopher McCarley   Daniel Morton

for

DEFENCE AND CIVIL INSTITUTE
OF ENVIRONMENTAL MEDICINE

TABLE of CONTENTS

SCHOOL of PHYSICAL and HEALTH EDUCATION

QUEEN'S UNIVERSITY

MINIMUM PHYSICAL FITNESS STANDARDS STUDY

PREAMBLE

The Canadian Armed Forces (CF) are currently developing Minimum Physical Fitness Standards (MPFS) for all military personnel. The underlying principle is that there are certain duties which all personnel, even those in otherwise sedentary jobs, must be able to perform if called upon in an emergency. Seven common tasks have been identified by the CF as being critical. Queen's University has been contracted to investigate the specific fitness requirements of the most difficult tasks.

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The purpose of this study is to identify and quantify those components of physical fitness involved in performing these tasks. Performance on common tasks will be compared to performance on standard test batteries.

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Thank-you for your participation in the development of physical fitness standards for the military.

MINIMUM PHYSICAL FITNESS STANDARDS STUDY for the CANADIAN FORCES

conducted by QUEEN'S UNIVERSITY SCHOOL of PHYS. ED.

Kingston Participant Schedules

Trenton Personnel

Group A:

Monday July 8

8:30- 9:00	Check in
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11:30- 1:00	Lunch
1:00- 4:00	Station 2 - Evacuation Task (track)

Tuesday July 9

8:30-11:30	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 4 - Entrenchment Dig (field)
5:00	Departure

Group B:

Monday July 8

8:30- 9:00	Check in
9:00-11:30	Station 4 - Entrenchment Dig (field)
11:30- 1:00	Lunch
1:00- 4:00	Station 1 - Queen's Station (centre tent)

Tuesday July 9

8:30-11:30	Station 2 - Evacuation task (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
5:00	Departure

Kingston Personnel - Land OPS

Group C:

Tuesday July 9

8:30- 9:00	Check in
9:00-11:30	Station 1 - Queen's Station (centre tent)
11:30- 1:00	Lunch
1:00- 4:00	Station 2 - Evacuation Task (track)

Wednesday July 10

8:30-11:30	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 4 - Entrenchment Dig (field)
5:00	Departure

Group D:

Tuesday July 9

8:30- 9:00	Check in
9:00-11:30	Station 4 - Entrenchment Dig (field)
11:30- 1:00	Lunch
1:00- 4:00	Station 1 - Queen's Station (centre tent)

Wednesday July 10

8:30-11:30	Station 2 - Evacuation task (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
5:00	Departure

Kingston Personnel - Support

Group E:

Wednesday July 10

8:30- 9:00	Check in
9:00-11:30	Station 1 - Queen's Station (centre tent)
11:30- 1:00	Lunch
1:00- 4:00	Station 2 - Evacuation Task (track)

Thursday July 11

8:30-11:30	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 4 - Entrenchment Dig (field)
5:00	Departure

Group F:

Wednesday July 10

8:30- 9:00	Check in
9:00-11:30	Station 4 - Entrenchment Dig (field)
11:30- 1:00	Lunch
1:00- 4:00	Station 1 - Queen's Station (centre tent)

Thursday July 11

8:30-11:30	Station 2 - Evacuation task (track)
11:30- 1:00	Lunch
1:00- 4:00	Station 3 - Low-High Crawl Task (centre track)
	Station 2 - Evacuation Task repeats (track)
5:00	Departure

MINIMUM PHYSICAL FITNESS STANDARDS STUDY: STATION SCHEDULE

Station 1: Queen's Station Schedule (John Thomson)

Monday July 8:	8:30-11:30	Group A - Trenton Air OPS
	1:00- 4:00	Group B - Trenton Air OPS
Tuesday July 9:	8:30-11:30	Group C - Kingston Land OPS
	1:00- 4:00	Group D - Kingston Land OPS
Wednesday July 10:	8:30-11:30	Group E - Kingston Support
	1:00- 4:00	Group F - Kingston Support

Station 2: Evacuation Task Schedule (Tim Lapp)

Monday July 8:	8:30-11:30	
	1:00- 4:00	Group A - Trenton Air OPS
Tuesday July 9:	8:30-11:30	Group B - Trenton Air OPS
		Group A repeaters - Trenton Air OPS
	1:00- 4:00	Group C - Kingston Land OPS
		Group B repeaters - Trenton Air OPS
Wednesday July 10:	8:30-11:30	Group D - Kingston Land OPS
		Group C repeaters - Kingston Land OPS
	1:00- 4:00	Group E - Kingston Support
		Group D repeaters - Kingston Land OPS
Thursday July 11:	8:30-11:30	Group F - Kingston Support
		Group E repeaters - Kingston Support
	1:00- 4:00	Group F repeaters - Kingston Support

Station 3: Low-High Crawl Task Schedule (Joan Stevenson)

Monday July 8:	8:30-11:30	
	1:00- 4:00	
Tuesday July 9:	8:30-11:30	Group A - Trenton Air OPS
	1:00- 4:00	Group B - Trenton Air OPS
Wednesday July 10:	8:30-11:30	Group C - Kingston Land OPS
	1:00- 4:00	Group D - Kingston Land OPS
Thursday July 11:	8:30-11:30	Group E - Kingston Support
	1:00- 4:00	Group F - Kingston Support

Station 4: Entrenchment Dig Task Schedule (Dan Morton)

Monday July 8:	8:30-11:30	Group B - Trenton Air OPS
	1:00- 4:00	
Tuesday July 9:	8:30-11:30	Group D - Kingston Land OPS
	1:00- 4:00	Group A - Trenton Air OPS
Wednesday July 10:	8:30-11:30	Group F - Kingston Support
	1:00- 4:00	Group C - Kingston Land OPS
Thursday July 11:	8:30-11:30	
	1:00- 4:00	Group E - Kingston Support

MINIMUM PHYSICAL FITNESS STANDARDS STUDY:

Kingston Daily Schedule

Monday July 8:	8:30-11:30	Trenton Air OPS, Group A: Station 1
		Trenton Air OPS, Group B: Station 4
	1:00- 4:00	Trenton Air OPS, Group A: Station 2
		Trenton Air OPS, Group B: Station 3
Tuesday July 9:	8:30-11:30	Trenton Air OPS, Group A: Station 3
		Station 2 (repeats)
		Trenton Air OPS, Group B: Station 2
		Kingston Land OPS, Group C: Station 1
		Kingston Land OPS, Group D: Station 4
	1:00- 4:00	Trenton Air OPS, Group A: Station 4
		Trenton Air OPS, Group B: Station 3
		Station 2 (repeats)
		Kingston Land OPS, Group C: Station 2
		Kingston Land OPS, Group D: Station 1
Wednesday July 10:	8:30-11:30	Kingston Land OPS, Group C: Station 3
		Station 2 (repeats)
		Kingston Land OPS, Group D: Station 2
		Kingston Support, Group E: Station 1
		Kingston Support, Group F: Station 4
	1:00- 4:00	Kingston Land OPS, Group C: Station 4
		Kingston Land OPS, Group D: Station 3
		Station 2 (repeats)
		Kingston Support, Group E: Station 2
		Kingston Support, Group F: Station 1
Thursday July 11:	8:30-11:30	Kingston Support, Group E: Station 3
		Station 2 (repeats)
		Kingston Support, Group F: Station 2
	1:00- 4:00	Kingston Support, Group E: Station 4
		Kingston Support, Group F: Station 3
		Station 2 (repeats)

Station 1: Queen's Station
Station 2: Evacuation Task
Station 3: Low-High Crawl
Station 4: Entrenchment Dig

MINIMUM PHYSICAL FITNESS STANDARDS STUDY for the MILITARY

conducted by QUEEN'S UNIVERSITY SCHOOL of PHYS. ED.

Halifax Participant Schedules

Sea OPS Personnel

Group A:

Monday July 15

8:30- 9:00	Check in
9:00-11:30	Teaching - Fire-fighting (upper equipment building)
11:30- 1:00	Lunch
1:00- 4:00	Station 1 - Fire-fighting test (bulkhead 1)

Tuesday July 16

8:30-11:30	Station 2 - Queen's Station (lower equipment building)
11:30- 1:00	Lunch
1:00- 4:00	Station 3 - Shipboard Evacuation Task (bulkhead 2)
5:00	Departure

Group B:

Monday July 15

12:30- 1:00	Check in
1:00- 4:30	Teaching - Fire-fighting (upper equipment building)

Tuesday July 16

8:30-11:30	Station 1 - Fire-fighting Task (bulkhead 1)
11:30- 1:00	Lunch
1:00- 4:00	Station 2 - Queen's Station (lower equipment building)

Wednesday July 17

8:30-11:30	Station 3 - Shipboard Evacuation Task (bulkhead 2)
12:00	Departure

Support Personnel

Group C:

Tuesday July 15

8:30- 9:00	Check in
9:00-11:30	Teaching - Fire-fighting (upper equipment building)
11:30- 1:00	Lunch
1:00- 4:00	Station 1 - Fire-fighting test (bulkhead 1)

Wednesday July 16

8:30-11:30	Station 2 - Queen's Station (lower equipment building)
11:30- 1:00	Lunch
1:00- 4:00	Station 3 - Shipboard Evacuation Task (bulkhead 2)
5:00	Departure

<u>Group D:</u>

Tuesday July 16

12:30- 1:00	Check in
1:00- 4:30	Teaching - Fire-fighting (upper equipment building)

Wednesday July 17

8:30-11:30	Station 1 - Fire-fighting Task (bulkhead 1)
11:30- 1:00	Lunch
1:00- 4:00	Station 2 - Queen's Station (lower equipment building)

Thursday July 18

8:30-11:30	Station 3 - Shipboard Evacuation Task (bulkhead 2)
12:00	Departure

MINIMUM PHYSICAL FITNESS STANDARDS STUDY

HALIFAX STATION SCHEDULE

Teaching Schedule

Monday July 15:	8:30-11:30	Group A - Sea OPS
	1:00- 4:00	Group B - Sea OPS
Tuesday July 16:	8:30-11:30	Group C - Support Personnel
	1:00- 4:00	Group D - Support Personnel

Station 1: Fire-fighting Schedule (Dan Morton)

Monday July 14:	8:30-11:30	
	1:00- 4:00	Group A - Sea OPS
Tuesday July 15:	8:30-11:30	Group B - Sea OPS
	1:00- 4:00	Group C - Support Personnel
Wednesday July 16:	8:30-11:30	Group D - Support Personnel

Station 2: Queen's Station Schedule (John Thomson)

Monday July 14:	8:30-11:30	
	1:00- 4:00	
Tuesday July 15:	8:30-11:30	Group A - Sea OPS
	1:00- 4:00	Group B - Sea OPS
Wednesday July 16:	8:30-11:30	Group C - Support Personnel
	1:00- 4:00	Group D - Support Personnel

Station 3: Shipboard Evacuation Task (Tim Lapp)

Monday July 15:	8:30-11:30	
	1:00- 4:00	
Tuesday July 16:	8:30-11:30	
	1:00- 4:00	Group A - Sea OPS
Wednesday July 17:	8:30-11:30	Group B - Sea OPS
	1:00- 4:00	Group C - Support Personnel
Thursday July 11:	8:30-11:30	Group D - Support Personnel
	1:00- 4:00	

MINIMUM PHYSICAL FITNESS STANDARDS STUDY:

Halifax Daily Schedule

Monday July 15:	8:30-11:30	Sea OPS, Group A: Teaching
	1:00- 4:00	Sea OPS, Group A: Station 1
		Sea OPS, Group B: Teaching
Tuesday July 16:	8:30-11:30	Sea OPS, Group A: Station 2
		Sea OPS, Group B: Station 1
		Support, Group C: Teaching
	1:00- 4:00	Sea OPS, Group A: Station 3
		Sea OPS, Group B: Station 2
		Support, Group C: Station 1
		Support, Group D: Teaching
Wednesday July 17:	8:30-11:30	Sea OPS, Group B: Station 3
		Support, Group C: Station 2
		Support, Group D: Station 1
	1:00- 4:00	Support, Group C: Station 3
		Support, Group D: Station 2
Thursday July 18:	8:30-11:30	Support, Group D: Station 3

Station 1: Fire-fighting Task
Station 2: Queen's Station
Station 3: Shipboard Evacuation Task

PROTOCOLS

QUEEN'S STATION

ILM TESTING

Purpose: to determine the maximum weight you can lift to a height of six feet and five feet.

Lifting Instructions
- For this test you will position your feet at a comfortable distance from the handles, about shoulder width apart.
- the handles will be grasped palms down.
- to start, have your arms straight, your back straight, your knees bent, and your neck hyper-extended (bulled).
- begin by first extending your knees and hips, and then by using your upper body to complete the lift.
- the weights must be lifted in one continuous motion to a primary weight of six feet and to a secondary height of five feet.
- upon completion of each lift, the subject will be allowed a rest period of no more than 30 seconds. (you will be given a 5 second warning before being expected to lift the next trial)
- if, during the lift, the weights come to a complete stop on the upward phase the trial will not be allowed.
- if this lift was at or above the five foot mark you will continue lifting heavier weights to the five foot marker.
- the rest period between the six foot and the five foot lifts will be extended to a maximum of sixty seconds to ensure adequate recovery time for the next series of lifts.
- thereafter the rest periods will return to 30 seconds.
- the test will end when the subject fails to lift to the five foot marker.
- the final scores for both tests will be recorded on the data sheet.

Protocols

Six Foot Lift
- after an adequate warm-up, the subject will be allowed three trial lifts at different weights in order to practice the lifting technique.
- the starting weight will be determined using a chart that considers the subjects mass and gender.
- the three trial lifts will be performed at a weight less than or equal to the starting mass.

1. the subject will face the ILM and await the instructions to begin lifting.
2. upon hearing the command "begin lifting" the subject will lift the weight to the six foot marker in one continuous motion, then lower it to the initial position
3a) IF the lift is SUCCESSFUL (velocity not = 0) THEN:

    i) for each successive lift the weight will be increased in five pound increments for women and ten pound increments for men.

ii) have the subject rest for a maximum of 30 seconds in preparation for the next lift. He/she will be informed of the following at the 25 second mark: " you have 5 seconds to begin lifting ".

3b) IF the lift is a FAILURE and the height reached is greater than five feet THEN:
   i) the subject may rest for a maximum of 60 seconds in preparation for the five foot lift. (see protocol for five foot lift)
   ii) the score of the previous successful lift is recorded as the maximum six foot lift.

OTHERWISE: the height reached is less than five feet, the test is over, and the five foot score equals the six foot score.

Five Foot Lift
- this is the secondary height for the ILM test and as such is a continuation of the six foot lift protocol.
- for each successive lift the weight will increase according to the six foot lift criterion
- the subject lifts until the weight cannot be raised to the five foot marker
- the test is over and the previous lift is recorded as the five foot lift score.

Cautions
- keep the back as straight as posible and the neck bulled
- during the initial phase if the lift, do not jerk the weight upward.
- leaning backward or arching forward are not acceptable lifting techniques.
- the subject may stop at any time if he/she feels that they cannot lift the next weight.

WINGATE TEST

The Wingate test is a maximal performance test of an individual's anaerobic power. It requires an all out effort on a stationary cycle ergometer for 30 s. The subject must be highly motivated to determine his/her maximal score.

Equipment:

-Monark cycle ergometer
-Monark arm ergometer
-Commodore 64 microcomputer, printer, monitor
-program cassette and tape recorder (plus an extra cassette)
-co-axial cable with BNC connecter (plus an extra)

Warm-Up:

The warm-up procedure for the leg ergometer test will consist of performance of the Astrand-Rhyming Test. A warm-up for the arm ergometer test will be accomplished through the ILM testing procedure. It is important that the subject be allowed a brief exposure to the arm ergometer at sub-maximal RPM's and workload.

Method:

a) Seat -should be adjusted to comfortable height on cycle ergometer (knee in extended position approx. 15 deg. with toe clips utilized). A seat belt must be secured around the hips for arm erg. testing.

b) Computer -The computer will prompt the tester for relevant subject information as listed below. Type in the requested information, pressing the "RETURN" key after each input.

Name
Social Insurance Number (SIN)
Workload: determined from the attached weight/workload table
Flywheel Circumference: 6 for the cycle (leg) erg.
2.4 for the arm erg.

c) Instructions - A subject should have the nature of the test outlined be informed that he/she must cycle as fast as possible for the entire test and not to preserve strength or pace him/herself. As well, he/she must remain seated throughout.

d) Protocol - On the command "start", the subject will begin cycling at maximum speed. The load must be applied within 4 s. of the onset of cycling. When the predetermined load has been reached, an assistant will press the "RETURN" key on the computer to start the 30 s. test.

e) Motivation - Verbal encouragement is beneficial. The last 5 s. of the test should be counted down as it appears on the screen.

f) Test Completion and Cool Down - At the end of the test, the load is quickly reduced to minimum resistance and the subject continues to cycle at his/her own rate, or in the case of the arm ergometer to cease cycling altogether but remain seated. This is important to prevent the pooling of blood. The subject may feel some nausea and should be allowed to cycle until he/she feels recovered (i.e., at least 2-3 minutes or until the heart rate decreases to <120 beats/min.).

g) Blood Lactate - Venous blood samples will be taken 3-5 minutes after completion of the leg ergometer test. The subject should be instructed to go to the appropriate station.

Subject Body Mass (kg)	Leg Erg Workload (kp)	Arm Erg Workload Women: (kp)	Men: (kp)
40	2.6	1.9	2.4
42	2.7	2	2.6
44	2.8	2.1	2.7
46	2.9	2.2	2.8
48	3.1	2.3	2.9
50	3.2	2.4	3.1
52	3.3	2.5	3.2
54	3.5	2.6	3.3
56	3.6	2.7	3.4
58	3.7	2.8	3.5
60	3.8	2.9	3.7
62	4	3	3.8
64	4.1	3.1	3.9
66	4.2	3.2	4
68	4.4	3.3	4.1
70	4.5	3.4	4.3
72	4.6	3.5	4.4
74	4.7	3.6	4.5
76	4.9	3.6	4.6
78	5	3.7	4.8
80	5.1	3.8	4.9
82	5.2	3.9	5
84	5.4	4	5
86	5.5	4.1	5
88	5.6	4.2	5
90	5.8	4.3	5
92	5.9	4.4	5
94	6	4.5	5
96	6.1	4.6	5
98	6.3	4.7	5
100	6.4	4.8	5

Skinfold Measurements

Four sites are measured-the triceps, biceps, subscapular and supra-iliac skinfolds.

Equipment: skinfold caliper

Procedure: Grasp the skinfold beteween the thumb and index finger 1 cm above and below the site and apply firm pressure. Lift the skinfold. Apply caliper jaws at right angles to the prescribed site. Release the spring handles fully but support the weight of the calipers in the hand. Read the measurement after the full pressure of the caliper jaws has been applied and the drift of the needle has ceased. Record to the nearest 0.5 mm. Repeat the measurement. If the difference is greater than 2 mm, take a third measure and record the mean of the closest pair.

Triceps Skinfold: Measure the back of the unclothed pendent right arm at a level midway between the tip of the acromion and the tip of the elbow, with the forearm flexed at an angle of 90 degrees. Lift the skinfold parallel to the long axis of the arm. Ask the subject to lower the forearm, then apply the calipers to the site.

Biceps Skinfold: Measure the front of the pendent right arm over the biceps, at a level midway between the acromion and the tip of the elbow. Lift the skinfold parallel to the axis of the upper arm.

Subscapular Skinfold: With the subject standing, measure about 1 cm below the angle of the right scapula. Lift the skinfold so that its crease runs at an angle of about 45 degrees downward from the spine.

Supra-iliac Skinfold: Measure 3 cm above the supra-iliac crest, with the fold running parallel to the crest.

Flexed Arm Hang

Equipment: Stop watch with sweep hand.

Protocol: Adjust the bar to the subjects height. Have the subject grasp the bar with a reverse grip, hands shoulder width apart. When the subject becomes airborne with the body held such that the bar is at eye level, timing stops. Record Hang Time to the nearest second.

Endurance Grip Hold

Equipment: Hand-grip dynamometer
Stopwatch with sweep hand.

Adjust Dynamometer handle to fit grip and hand of subject. With first the right hand, and then the left hand, the subject squeezes the grip until the dial reads 20 kilograms, and then the timing begins. When the subject is no longer able to hold the needle at 20 kg, the timing is stopped. Grip time, to the nearest second, is recorded.

Prediction of Maximal Aerobic Capacity

Equipment: Mechanically braked bicycle ergometer
Metronome (set so that a person following its beat will be pedalling at 50 revolutions per minute).

Directions:

1. Set the work load of the bicycle ergometer so that your target heart rate while pedalling at 50 revolutions per minute will be between 140 and 160 beats per minute. (The work load setting is usually between 450 and 900 kilogram-meters and depends on the level of aerobic fitness, age, sex, etc., of the subject.)

2. Pedal for 6 minutes, counting heart rate (by palpitation) over the last 15 seconds of each minute. (Then multiplied by 4 to obtain the number of beats per minute.) After the second or third minute, you may have to adjust the ergometer work load so that the target heart rate (140 to 160 beats per minute) is achieved. The particular workload is recorded.

3. Over the final 3 minutes of this 6-minute test your heart rate remain constant, between 140 and 160 beats per minute. This average, steady heart rate is used to predict aerobic fitness. Record the heart rates, in beats per minute.

Nomogram for Predicting Maximum O_2 Consumption

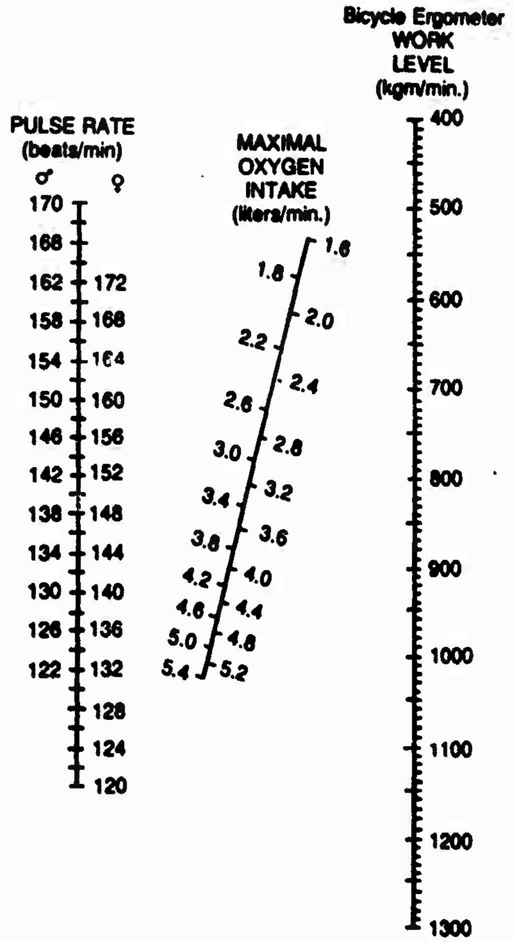

FIGURE 7.26 Prediction of aerobic fitness by submaximal exercise on the bicycle ergometer. Locate your pulse rate in the male (♂) or female (♀) scale on the left. On the right-hand scale locate your bicycle ergometer work load. Draw a straight line connecting the two points. Where this line intersects the middle scale is the reading of your predicted maximal oxygen consumption. *Source*: Adapted from P.-O. Astrand and I. Rhyming, "A Nomogram for Calculation of Aerobic Capacity (Physical Fitness) from Pulse Rate during Submaximal Work," *Journal of Applied Physiology*, 7 (1954) 218-221.

Land Evacuation Task

The purpose of this task is to carry the stretcher a distance of one kilometre as quickly as possible. This is a simulation of the evacuation of injured personnel.

Equipment Required

- 4 stretchers
- 15 subjects
- 4 carrying straps
- 4 80 Kg sandbags
- super-subjects
- 2 stop watches (digital)
- 20 pylons

Field Set-up

- the stretcher carry will take place at the 400 m track
- cones will be placed 50 metres apart around the course

Protocol

Initial Position:

- the starting position (front or back of stretcher) will be randomly assigned.
- the subject will grip the stetcher handles as follows:
  - a) back position - arms at the side
    - palms facing medially
  - b) front position - same as above

Subject Performance:

- the subject may walk at a brisk pace during the carry
- running is not allowed
- if the subject desires a rest, the stretcher must be lowered to the ground and not dropped!
- the frequency and duration of the rest periods will be left to the discretion of the subject.
- the subject may switch to the other end of the stretcher at any point in the carry.
- the distance remaining will be announced periodically
- the task ends after 2.5 laps have been completed.
- the time for completion of the task will be recorded.

Data Collection:

a) a 10 second pulse count will be measured prior to the test to establish resting HR.
b) HR will be recorded periodically throughout the carry until the completion of the task
c) the time and distance to the first rest will be recorded
d) time of completion will be recorded, and a final heart rate taken

Note:

a) Some subjects may have their heart rate monitored throughout using telemetry.

b) Those people who failed the original task (took longer than 20 min.) will return to perform the task using the carrying straps. These individuals will be not be paired with a super-subject, but with another failure.

<u>Instructions to Subjects</u>

The subject should be informed of the following points prior to test commencement:

- The test is a simulation of an evacuation of injured military personnel for 1 km and therefore must be performed as quickly as possible.
- The starting position must be the front, but subjects may alternate thereafter at their own discretion.
- The subject may walk quickly, but must not run.
- The stretcher must be lowered during a rest and <u>must not</u> be dropped.

<u>Instructions to Super-Subjects</u>

- Carry the stretcher at the subjects pace, not your own.
- If fatiguing, use your partner to take one of your handles, or switch entirely <u>but</u> only during one of the subject's rest stops.
- There are shoulder straps available. These may be useful during the initial stages of the task when the rest stops are spaced farther apart.

LOW/HIGH CRAWL

Equipment:
- 2 rifles with slings (1 for test, 1 for practise)
- 3 pylons
- stopwatch
- tape measure (50 m)

Field Set-Up: - Three pylons placed in a straight line. The first two 15 m apart, and the third 30 m from the second. The second pylon will be considered the "start" pylon.

Method:
- the subject starts in a prone position with both hands on the rifle
- on the command "go" the subject will begin a low crawl towards a pylon 30 m in front of him/her
- at 30 m the time is recorded, and the subject gets to his/her hands and knees, pivots 180 degrees and starts a high crawl back to a pylon 45 m away. During the high crawl, the gun may be slung over the back and secured, or dragged in one hand.
- at the finish the time is recorded, and a heart rate taken.
- a venous blood sample will be taken 5 minutes after the completion of the task at the Queen's Testing Tent

Notes:
- Many subjects will have their heart rates monitored using telemetry. The electrode positions will be identified,the skin cleaned with a mild abrasive and alcohol and a transmitter positioned on the subject's waist prior to testing. The electrodes must be carefully placed to avoid any harm coming to them during the crawl.

ENTRENCHMENT DIG

The purpose of this task is to dig an entrenchment, measured 2'* 6'* 18", as quickly as possible. This task is designed to replicate battlefield conditions.

Equipment Required

- 10 shovels
- gloves
- 2 wooden measuring frames
- trench markers
- 2 stopwatches
- 2 straight sticks

Set-up

- this task is located at the CFB garden site.
- for each subject, one 2'* 6' ditch will be marked with a white lime outline.

Protocol

- the subject stands at one end of the trench with the shovel at his/her side.
- the subject will verbally be instructed to commence digging.
- the subject will dig on the inside border of the white lime
- all soil will be piled on either side of the ditch approximately 2'-3' away from the sides.
- avoid tossing the soil toward other ditches.

Subject

- the subject may rest at any point during the task.
- excessive forward bending should be avoided in order to reduce the stress on the lower back.
- the experimenter will determine when the task has been completed.

Data Collection

- the time to complete the dig will be recorded.
- HR will be recorded at time = 0 min., 5min., and at the completion of the task.
- to record HR, the experimenter will take a 10 sec pulse count from the carotid artery. Care must be taken not to press too hard when obtaining this measurement.
- the wooden measuring frame will be used to determine when the dig is completed.
- upon completion of the task the subject will be asked questions regarding localised and general fatigue.

TEACHING STATION FOR FIREFIGHTING

PURPOSE

The purpose of the teaching station is to prepare military personnel with the knowledge and skills to permit them to fight fires on board a ship. Such fires would primarily be oil-spill fires so the techniques taught at this station relate to that task.

METHOD

The design of the actual fire fighting task will require each subject to use the low velocity hose to put out 6 pan fires up one flight deck. (See Fire Fighting Protocol for a more detailed report).

In order to accomplish this goal, personnel will require training in the following:

a) clothing requirements for task.

b) instruction on use and safety with breathing apparatus

c) training in techniques of fighting large and small fires (primarily oil).

d) holding and use of high and low velocity nozzles while going up and down a staircase.

e) instruction to peronnel who are in charge of managing the hoses.

f) any additional fire fighting items that you feel should be required knowledge for military personnel in a fire fighting role.

Fire Fight

The subject will extinguish six fires wearing fire fighting gear and a Chemox Self-Contained Breathing Apparatus (SCBA). Between fires the subject will be required to ascend and descend one deck while controlling 15 m of charged hose.

Equipment

- 6 fire fighting outfits (i.e., boots, pants, coat, gloves)
- 2 Chemox SCBA
- 2 low velocity nozzles
- data collection sheets
- fire bins, fuel, water

Method

- the subject starts 10 m from the foot of the stairs outfitted in the fire fighting gear and breathing through the Chemox SCBA
- 2 assistants, also wearing the firefighting gear, will help carry the trailing hose. (They will not use the Chemox SCBA).
- On the command 'START', the subject will move quickly to the stairs and climb up with the hose charged at 100 lb. and a low velocity adaptor attached and in the 'OFF' position (handle in the forward position)
- Upon reaching the bin fire on the upper deck, the subject will turn the nozzle on (mid-position) and proceed to extinguish the fire.
- Proper technique must be used by the subject (i.e., angle of nozzle, frequency of rotation, hand grip).
- After the investigator has determined that the fire is out and signalled such to the subject, the latter will back down the stairs to the bottom with the nozzle off.
- Upon reaching the bottom of the stairs, the subject will repeat the task as outlined above. A total of six fires must be extinguished.
- After the 6th fire, the subject will climb back down the stairs and will be considered finished when he/she reaches the foot of the stairs.
- HR will be monitored throughout, taken by pulse at the beginning and the end of the task. Some subjects may have their HR monitored with a telemetry unit.

Note:

- Proper hand grip means that the forward hand must not be used to hold onto the shaft of the low velocity nozzle.
- The subject cannot switch hand position during the fight.
- The test will be stopped because: 1) inadequate respiration from the Chemox SCBA; 2) muscle fatigue prohibiting safe, useful techniques; or 3) the attainment of 30 min. before task completion.

Subject Instructions

- Perform the task while following safe practices.
- Do not move the nozzle handle into the back position (starting the high velocity jet).
- Use proper techniques.
- Look to the investigator to signal extinguishment.

Shipboard Evacuation Task

The task is a simulation of a casualty evacuation during a fire onboard ship. The subject is required to carry an 80 kg Stoker (or Robertson) up and down one deck.

__Equipment__

- Stoker or Robertson stretcher with an 80 kg load.
- guide ropes with clips
- 2 fire-fighting outfits (i.e., gloves, coats, pants boots)
- data collection sheets

__Method__

- Subjects will be matched on upper body strength as determined by the ILM Lift to 5'.
- Subjects will be outfitted in fire-fighting gear.
- The team will start 12.5 m from the foot of the stairs.
- On the command "START", the team will carry the stretcher 15m and the ascend the stairs. Both partners must reach the top deck.
- At the top, a HR may be taken by the investigator (this is not the case if the HR's are being telemetered.)
- The team may descend the stairs as soon as they are ready. The test is complete when the team reaches the bottom and returns the stretcher to the starting position. (A final HR may be taken by the testor).

__Instructions to Subject__

- The test is a simulation of an evacuation of military personnel and therefore must be performed as quickly and as carefully as possible.
- Bend the knees to execute the lift rather than bending the back excessively.
- Subjects will be timed for vasrious stages of the task and judged if they can complete the task in a reasonable and safe amount if time.
- There will be a safety rope on the stretcher for all groups in case someone slips during stair ascent and descent.
- A blood sample will be taken at the end of the task and compared to the Queen's test data.